E. J. Whitby.

THE

USEFUL ARTS

EMPLOYED IN

THE PRODUCTION OF

CLOTHING.

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INTRODUCTION.

A SLIGHT inquiry into the nature of the employments of our fellow-men will suffice to show that a very large proportion of them is devoted to the production of Clothing.

"Observe the accommodation of the most common artificer or day-labourer, in a civilized and thriving country, and you will perceive, that the number of people, of whose industry a part, though but a small part, has been employed in procuring him this accommodation, exceeds all computation. The woollen coat, for example, which covers the day-labourer, coarse and rough as it may appear, is the produce of the joint labour of a great multitude of workmen. The shepherd, the sorter of the wool, the woolcomber or carder, the dyer, the spinner, the weaver, the fuller, the dresser, with many others, must all join their different arts, in order to complete even this homely production. How many merchants and carriers, besides, must have been employed, in transporting the materials from some of those workmen to others, who often live in a very distant part of the country! How much commerce and navigation in particular, how many ship-builders, sailors, sail-makers, rope-makers, must have been employed, in order to bring together the different drugs made use of by the dyer, which often come from the remotest corners of the world! What a variety of labour, too, is necessary in order to produce the tools of the meanest of those workmen! To say nothing of such complicated machines, as the ship of the sailor, the mill of the fuller, or even the loom of the weaver, let us consider only what a variety of labour is

requisite in order to form that very simple machine, the shears, with which the shepherd clips the wool. The miner, the builder of the furnace for smelting the ore, the feller of the timber, the burner of the charcoal to be made use of in the smelting-house, the brick-maker, the brick-layer, the workmen who attend the furnace, the mill-wright, the forger, the smith, must, all of them, join their different arts in order to produce them. Were we to examine, in the same manner, all the different parts of his dress and household furniture, the coarse linen shirt which he wears next his skin, the shoes which cover his feet, the bed which he lies on, and all the different parts which compose it, the kitchen-grate at which he prepares his victuals, the coals which he makes use of for that purpose, dug from the bowels of the earth, and brought to him, perhaps, by a long sea and a long land carriage, all the other utensils of his kitchen, all the furniture of his table, the knives and forks, the earthen or pewter plates upon which he serves up and divides his victuals, the different hands employed in preparing his bread and his beer, the glass window which lets in the heat and the light, and keeps out the wind and the rain, with all the knowledge and art requisite for preparing that beautiful and happy invention, without which these northern parts of the world could scarce have afforded a very comfortable habitation, together with the tools of all the different workmen employed in producing these different conveniences:—if we examine, I say, all these things, and consider what a variety of labour is employed about each of them, we shall be sensible, that, without the assistance and co-operation of many thousands, the very meanest person in a civilized country could not be provided, even according to what we very falsely imagine the easy and simple manner in which he is commonly accommodated. Compared, indeed, with the more extravagant luxury of the great, his accommodation must, no

doubt, appear extremely simple and easy; and yet it may be true, perhaps, that the accommodation of a European prince does not always so much exceed that of an industrious and frugal peasant, as the accommodation of the latter exceeds that of many an African king, the absolute master of the lives and liberties of ten thousand naked savages."*

The object of the present treatise is to illustrate in detail a portion of the above text, by tracing the natural history, production, preparation, modes of manufacture and statistics, of the principal substances employed in the production of Clothing.

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* Dr. Adam Smith. *Inquiry into the Nature and Causes of the Wealth of Nations.*

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The
Useful Arts employed in the Production of Clothing.

Chapter I.

ON THE MATERIALS USED FOR CLOTHING.

Nature has granted to every animal except man a covering sufficient to protect him from the inclemency of the weather. The lion of the tropics, and the shaggy bear of the polar regions, are equally fitted to contend, the one against the heat, and the other against the cold, which characterize those strikingly different portions of the surface of the globe: the lion does not sink under the burning sun of Africa; nor does the white bear require any coat but that which nature has given him to resist the piercing frosts of Greenland. But man—feeble even in his strength—must provide artificially a covering to protect him from chilling cold; and although the natives of some hot countries live from infancy to old age almost entirely without clothing, the low state of mind among them seems to show that man, in order to maintain his supremacy among created beings, must labour, by the "sweat of his brow," to procure coverings in some respect analogous to those with which other animals are provided by nature. The Almighty has strewn the beautiful face of the earth with gifts profitable and pleasant to man; but it appears to be wisely ordained, that man shall not enjoy them without bringing into active exercise his powers both of mind and body. Thus it is with regard to clothing, as well as to many other of the necessaries of life: the raw materials are presented to us in abundance; but we must bestow *labour* on them before they are fit for our use.

In every country removed from absolute rudeness and barbarism, we find that the larger portion of the materials composing the apparel of mankind consists of *woven* cloth, a fabric made of fibrous threads, which adhere to one another by being interlaced. This character, it will be perceived, applies to all the various cloths manufactured from cotton, wool, flax, hemp, and

silk, however different may be the sources of these materials: cotton consists of fibres taken from the seed-pod of the cotton plant;—flax and hemp, of a fibrous bark or rind of two well-known plants;—wool, of the soft covering which nature affords to the sheep and a few other animals;—and silk, of a beautifully minute thread which is furnished by the silkworm; yet, various as are these sources, the fibrous or hairy material thus yielded, is, in each case, capable of being spun into a tenacious yarn or thread, and this yarn of being woven into a continuous cloth or tissue, from which garments can be made.

Almost the only other substance from which the larger garments have been made, is the skins of animals, more or less prepared after having been removed. The close texture of the skin enables it to resist moisture to a great extent; while the hair or fur, with which it is in most cases covered, enables it to resist cold. We are in the habit of saying that furs constitute *warm* garments, as if the fur itself were warm; but what really occurs is this, that the fur prevents the natural warmth of the body from escaping, when the atmosphere is cold:—we do not put on garments to "keep out the cold," but to keep *in* the warmth, since the blood flowing through the system is nearly or quite as warm in mid-winter as in mid-summer.

The Indian warriors in the American prairies, as well as other nations slenderly acquainted with the arts of civilized life, kill the bison, or the ox, or whatever animal their country affords,—eat the flesh, if it be such as will gratify their palate,—and convert the skins into garments. It generally happens in such cases, that those animals which furnish the most nourishing food are not those which possess the warmest or most beautiful furs; but nature is seldom so chary of her gifts as to limit the supply of animals too narrowly to admit of some species being caught for the purposes of food, and others for the sake of their furs.

The skins, among such nations as those to which we have referred, are seldom otherwise prepared than by drying; for the process of *tanning*, by which the membranous portion, after being deprived of the fur, is converted into *leather*, is one requiring much of that intelligence and many of those resources which can only be met with in civilized life. There is scarcely any intermediate step between the use of the unprepared skins of animals, and that of a woven fabric formed of threads. Consequently, we find, that at a very early period in the history of the human race, mention is made of woven cloths, formed of some fibrous material, sometimes one of those before-men-

tioned, at other times of gold or silver thread. It may be interesting to take a rapid glance at the use of woven or textile fabrics for clothing, in past ages. It is a subject not a little connected with the advance of nations in civilization.

The manufacture of cotton owes its birth to India, where it has existed for thousands of years; for, to say nothing of traditionary report, Herodotus, who wrote twenty-three centuries ago, distinctly mentions the cotton fabrics of India, saying that a species of plant in that country bears a fruit full of wool, superior to that of the sheep, with which the natives make cloth for their garments: this "wool-bearing plant" is the cotton-tree. Arrian and Strabo likewise mention the cotton fabrics of India; and so little have the manners and arts of the Hindoos changed, that a description of the cotton manufacture at Baroche, a town in the north-west part of India, which was written in the second century of our æra, almost exactly agrees with the present practice. The manufacture at Baroche is said by Forbes to be very considerable, employing thousands of men, women, and children, in the production of fabrics from the finest muslin to the coarsest sail-cloth. The cotton weavers and spinners generally reside in the suburbs; and the weavers' houses are mostly near the shade of tamarind and mangoe trees, under which, at sunrise, they fix their looms.

Neither the Jews, the Egyptians, the Greeks, nor the Romans, appear to have known much of the cotton manufacture. Dr. Ure remarks, "If we consider how near to Syria and Egypt are the regions where the cotton shrub was indigenous, we may feel surprised that it should have remained so long unknown, or neglected by nations to whom it would have furnished a far cheaper and more comfortable article of dress than the flax plant. Indeed, the insulation of the cotton manufacture in India, for so many centuries after a considerable intercourse with the East had been established by the conquests of the Greeks and the Romans, is one of the most singular phenomena in the history of man, and shows how little inquisitive these highly celebrated people were concerning the arts conducive to personal comfort."

It seems probable that the followers of Mahomet were the first to bring the cultivation and preparation of cotton into western countries, after they had conquered the immense range of country from India to Barbary; but nothing certain appears to be known till about the thirteenth century, when Marco Polo, the traveller, found that, near the town of Mosul in Persia, the cotton plant was cultivated

in abundance, and woven fabrics were made from it. From *Mosul* is derived the name of *muslin*, which we apply to a fine description of cotton fabric.

When the Mahometans conquered Spain, they introduced the cotton manufacture into that country, where it flourished considerably in the thirteenth, fourteenth, and fifteenth centuries. Our word *fustian* is derived from the name *fustaneros*, signifying *substantial*, which the Spaniards applied to a stout kind of cotton goods.

In the same manner as the Moors brought the manufacture of cotton into Spain, so did they likewise cause it to be gradually cultivated and woven in various parts of Africa and Asia. It is not among the least remarkable instances of the mystery in which the early history of America is involved, that when Mexico was first discovered, the natives were found to be clothed in garments of beautiful cotton cloth, finely-woven, and of diversified colours. A few days after Cortes arrived in Mexico, he despatched to the Emperor Charles V., in July, 1519, among other rich presents, a variety of cotton mantles, some white, others chequered with white and black, or red, green, yellow, and blue; on the outside rough, like a shaggy cloth, and on the inside without either colour or nap. A number of under-waistcoats, handkerchiefs, counterpanes, tapestries, and carpets, all made of cotton, were likewise sent to Europe. Whether the Mexicans derived the manufacture from India, or whether it was the result of their own inventive ingenuity, it is now impossible to determine.

Italy, Holland, the Netherlands, England, France, and other European countries, successively introduced the cotton manufacture among them, and from thence commenced that continuous chain of improvement (particularly in England) which has brought the cotton manufacture to such a wondrous importance. The Hargreaves, the Arkwrights, and the Cromptons we can only mention with honour and respect, but we cannot attempt to detail the nature of their labours. Suffice it to say, that there is now scarcely a district in any civilized part of the globe where cotton cloth is not known.

It may here be remarked, that the introduction of cotton into England did not take place at so early a period as some documents would seem to indicate. Thus Leland, in his *Itinerary*, spoke of Bolton, three centuries ago, in the following terms:—"Bolton-upon-Moore market standeth most by *cottons:* divers villages in the moores about Bolton do make *cottons.*" Other writers speak similarly; but it has lately been shown with tolerable certainty, that cotton was

not then known in England; that the fabrics alluded to were made of woollen; and that "cottons" implied a close-fitting garment, or at least a woven fabric fitted for making into such garments. The word, as applied to a close-fitting garment, without reference to the material whereof it is made, has been traced through an extensive range of languages.

The manufacture of linen may be referred to a higher antiquity than that of cotton. Cruden has collected more than twenty allusions to it from the Holy Scriptures, some of them relating to periods of very high antiquity. A few may be quoted here. For instance, Deut. xxii. 11, "Thou shalt not wear a garment of divers sorts, as of woollen and linen together." Lev. xix. 19, "Neither shall a garment mingled of linen and woollen come upon thee." Lev. xvi. 23, "And Aaron shall come into the tabernacle of the congregation, and shall put off the linen garments." 1 Sam. ii. 18, "Samuel ministered before the Lord, being a child, girded with a linen ephod." 1 Kings, x. 28, "Solomon had horses brought out of Egypt, and linen yarn."

The swaddling bands so profusely wrapped round the mummies of Egypt are generally made of *linen*. Linen was, in fact, the clothing material of that industrious nation; it was held in such high esteem as to be used as a raiment by royalty, and diligently imitated by the neighbouring nations. The Jews, Greeks, and Romans probably derived their knowledge of the linen manufacture originally from the Egyptians. Alexander Severus was the first Roman emperor who wore linen; but the use of it did not become common until long after his time.

From Rome or its dependent provinces the linen manufacture extended to various parts of Europe; but it appears to have been in the British Isles that it has made most progress. It is supposed to have been carried on uninterruptedly since the time when the Romans conquered Britain; and has ever since formed an important part of British manufacture, particularly in Ireland and Scotland. Irish linens have hitherto maintained a certain degree of preponderance over others; but within the last few years the linen manufacture at Dundee in Scotland has advanced with strides as rapid as those which have distinguished the cotton manufacture at Manchester; while in and around Barnsley in Yorkshire, consequent, perhaps, on the vicinity of the very large flax-mills at Leeds, a considerable linen trade has sprung up.

The use of *woollen* garments is of high antiquity. They are frequently mentioned in the Bible; and when we con-

sider how universally sheep have been bred for their flesh, it is natural to expect that the employment of the wool as a material for clothing would follow. At a very early period domestic sheep were extensively spread over Western Asia. Pliny informs us, that Nicias of Megara discovered the art of fulling cloth; the property which wool possesses of being felted was however known in the East at a much earlier period, and probably gave rise to the first manufacture of woollen goods. The process of felting will be described hereafter; but it may be stated here, that it is a property by which the filaments of wool, when moistened and pressed, curl and twist among each other so as to form a tough fabric. When this property was once discovered, the knowledge of the art was soon widely spread. The tents of many of the Arabs and Tartars are, at the present day, made of felt from the wool of sheep, mingled with the hair of goats, camels, and other quadrupeds, and may be considered as a memento of the original art of cloth-making.

The weaving of wool into cloth seems to have been known as long back as fifteen hundred years before the Christian æra. We possess little information respecting the woollen manufactures of the Greeks and Romans, as distinct from the simple spinning and weaving which formed parts of female domestic employment. That the Romans had carried the manufacture of fine woollen cloth to a high degree of perfection, is an opinion supported by many circumstances, particularly by the great attention paid to the cultivation of fine-wooled sheep, and by the high prices at which the wool and the sheep were sold. Wool was the material of nearly all the garments worn by the Romans; and as the climate was warm, they endeavoured to spin and weave the wool into as fine and light a fabric as possible.

When Rome was overrun by barbarians, the woollen as well as other manufactures were thrown into confusion; but the comfort of warm and decent clothing was too important to allow such an art to fall into oblivion; and we consequently find that that country which we now call Holland and Belgium, became the seat of this important manufacture. A recent writer observes, "The woollen manufacture began to revive, and became the separate occupation of one class of the community, about the middle of the tenth century, in the Low Countries, where it remained the glory of the people, and the source of their opulence, through more than four hundred years. The wool which it consumed for the first few years was the produce of their own pastures, which had but lately been

reclaimed from the forest; but as the manufacture extended itself, the demands became larger, and were supplied from a greater distance. The wealth which it distributed was soon visible, and people crowded into the country, engaged in its commerce, and pushed their speculations with increasing vigour through one hundred and fifty years, when an inundation of the sea threatened to involve the art, the artist, and the country, in one general destruction. The dispersion of the people who fled from the calamity which appeared to overwhelm their hopes, instead of destroying the infant manufacture, gave it additional vigour, and was the means of establishing a connexion between the Netherlands and foreign countries, which proved of the highest importance to commerce. It contributed to a much more speedy recovery of the arts connected with the woollen manufacture, from the ruin which seemed to threaten them, and gave a striking instance of their partiality for the seats where they have once flourished, under the patronage of a government liberal enough to encourage, and sufficiently powerful to protect them, even in situations attended with natural disadvantages."

The woollen manufacture flourished about the same time in Spain with marked success, insomuch that when the Christian princes expelled the Moors from that country, there were found in Seville, in 1248, no less than 16,000 looms for weaving. Spain gradually shook off the yoke of the Mahometans, who had possessed that country for several centuries; but the intemperate manner in which the Moors were driven from the country, inflicted a lasting injury on the commerce and manufactures of Spain, from which it has never yet recovered.

Italy and France afterwards took up the manufacture; and in the latter country it soon attained a high degree of importance. England, as has been said, was familiar with some sort of woollen manufacture in the time of the Romans. A long interval then occurs in our knowledge of the state of that branch of industry; but it appears that the introduction of foreign weavers, and most probably a consequent improvement in the modes of working, took place in the reign of William the Conqueror, when a number of Flemings were driven out of their own country by an encroachment of the sea, and took refuge in England. From that time the woollen manufacture has continued to improve in England, and has increased to such an extent, that till the comparatively recent and unparalleled extension of the cotton manufacture, that of wool was deemed the *staple* or principal exercise of English manufacturing

ingenuity. It is from this circumstance that the custom arose of seating the Speaker of the House of Lords (the Lord Chancellor) on a *woolsack*, as a kind of legislative acknowledgment of the importance which is and ought to be attached to the productive industry of a country.

Russia, Sweden, Norway, and other northern countries have only recently entered on this branch of manufacture; consequently the extent to which it has arrived is not such as to call for particular notice; especially, as we here confine our attention chiefly to a brief notice of the *early* employment of woven fabrics among different nations.

Lastly, a few words may be said respecting *Silk*. This beautiful material was evidently much prized by the Jews and other nations alluded to in the Holy Scriptures, as such passages as the following testify:—"Pharaoh arrayed Joseph in silk;" "Her clothing is silk and purple;" "And I covered thee with silk;" "Thy raiment was of silk and broidered work;" "No man buyeth her merchandise of silk."

It has been observed, as a wonderful fact, "that the thick velvet and the stiff brocade, the thin gauze, and the delicate blonde, should all be formed from the product of the labours of a little worm;" and it is not unreasonable that we should wish to know something of the first application of silk to the purposes of clothing. This however, cannot with much success be done. The Chinese state that the art was known among them nearly three thousand years before the Christian æra; and whether we give credence to this statement or not, it seems at least probable that they were the first people who manufactured silk.

It appears that the *rearing* of the silk-worm was wholly confined to the Chinese till the time of the Emperor Justinian, although the manufacture of the silk into fabrics was carried on in Persia, Tyre, the Archipelago, and other countries. Silk was but little known in Europe till the time of Augustus, for only a small quantity reached Rome, and that was by a circuitous and expensive land and water-carriage. It was first worn by the females of rank, and gradually came to be used by those of lower station; those who could not afford the costly luxury of pure silk, purchased a fabric in which silk formed one part, and some coarser material the remainder. The Chinese silks were conveyed by the Persian caravans across the whole width of Asia, from China to Syria, and thence to Rome. During the time of Aurelian the best Chinese silk sold for its weight in gold.

From Rome the desire for silken dresses extended to

Byzantium (now Constantinople), and the Persians derived extraordinary profits by being the agents between the producers and consumers. This led the Emperor Justinian to suppose that he might draw a considerable revenue by imposing a tax on the imported silk; and he did so with such a short-sighted eagerness as to entirely frustrate his own plans; he laid an enormous tax, and ordered that the merchants should not sell above a certain price. This senseless interference with private traffic ruined the merchants, deprived the Constantinopolitans almost entirely of silk, and prevented the royal treasury from gaining anything by the tax.

The emperor's severity, however, had the effect of introducing the cultivation of the silk-worm into Europe. The circumstances are thus detailed by a recent writer:—

"The commerce of the Romans was in this state, as regarded the article of silk, when they obtained relief in a very extraordinary and unexpected manner. Two Persian monks, having been employed as missionaries in some of the Christian churches, which, according to Cosmas, were already established in different parts of India, had penetrated into the country of the Seres, or China. There, amidst their pious occupations, they viewed with a curious eye the common dress of the Chinese, the manufactures of silk, and the myriads of silk-worms, whose education, either on trees or in houses, had once been considered the labour of queens. They soon discovered that it was impracticable to transplant the short-lived insect, but that in the eggs a numerous progeny might be preserved, and multiplied in a distant climate. They observed with interest the labours of the little creatures, and strove to make themselves acquainted with all the manual arts employed in working up its productions into so great a variety of fabrics. On their return to the West, instead of communicating their knowledge thus acquired to their own countrymen, they proceeded on to Constantinople. The prospect of gain, or, as some have asserted, an indignant zeal, excited by seeing a lucrative branch of commerce engrossed by unbelieving nations (*i.e.* the Persians, &c.,) prompted them to impart to the emperor the secret, hitherto so well preserved by the Chinese, that silk was produced by a species of worm, and to acquaint him with their belief, that the eggs of these might be successfully transported, and the insects propagated in his dominions. They likewise explained to Justinian the modes of preparing and manufacturing the tender filament, mysteries hitherto altogether unknown, or but imperfectly understood in Europe. By the promise of a great

reward, the monks were induced to return to China, and there, with much difficulty, eluding the vigilant jealousy of the Chinese, they succeeded in obtaining a quantity of silk-worms' eggs. These they concealed in a hollow cane; and at length, in the year 552, conveyed in safety to Constantinople. The eggs were hatched in the proper season by the warmth of manure, and the worms were fed with the leaves of the wild mulberry-tree. These worms, in due time, spun their silk, and propagated under the careful tendance of the monks; who also instructed the Romans in the whole process of manufacturing their production. The insects thus produced were the progenitors of all the generations of silk-worms which have since been reared in Europe and the western parts of Asia—of the countless myriads whose constant and successive labours are engaged in supplying a great and still increasing demand. A caneful of the eggs of an Oriental insect thus became the means of establishing a manufacture which fashion and luxury had already rendered important, and of saving vast sums annually to European nations, which, in this respect, had been so long dependent on, and obliged to submit to, the exactions of their Oriental neighbours."*

Thus did the silk-worm become domiciled in Europe; and the history of the last thirteen hundred years has shown the attempts of various nations to cultivate the silk-worm, or, at least, to manufacture the silk after the worm has produced it. For six hundred years after the reign of Justinian, the silk cultivation spread but little from the Constantinopolitan Empire: the other countries of Europe were, generally speaking, in too rude or disturbed a state to profit much by such undertakings. When, however, about the twelfth century, the Italian states had risen to some importance, the silk manufacture extended its range. Roger the First, King of Sicily, invaded the territories of the Empire, carried off the wealth of Athens, Thebes, Corinth, and other towns, and led into captivity a considerable number of silk-weavers, whom he settled at Palermo, obliging them to impart to his subjects the knowledge of their art. The act was a despotic one; but the effect was, that in twenty years the silks of Sicily attained a decided excellence, being of diversified patterns and colours, some fancifully interwoven with gold, and others richly adorned with figures. By degrees the rearing of the worms and the manufacture of the silk became known over the whole of Italy

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* *Cabinet Cyclopædia*, "Silk Manufacture."

and Spain. Bologna, Modena, Florence, Venice, and other towns, found that commercial and financial advantages resulted from the encouragement of this branch of industry: indeed, in the last-mentioned city, the nobles did not disdain to embark in it, considering that the manufactures of silk, of glass, and of drugs, were not beneath the dignity of grandees: the fact probably was, that a little pride was sacrificed to much profit.

The manufacture was introduced into France during the reign of Francis I., and soon rose to importance. Lyons, the chief city in the south of France, has always been the principal seat of the silk-trade in that country.

Silk was woven in England in the fourteenth century; but to an extent quite unworthy of notice. Henry the Eighth thought it a great point to be able to obtain a pair of silk stockings from Spain to wear on gala days, instead of the usual cloth hose; and Queen Elizabeth was not a little proud at receiving a pair of silk stockings from her silk-woman, Mrs. Montague, and was so much delighted with them, that she never afterwards condescended to wear stockings made of cloth.

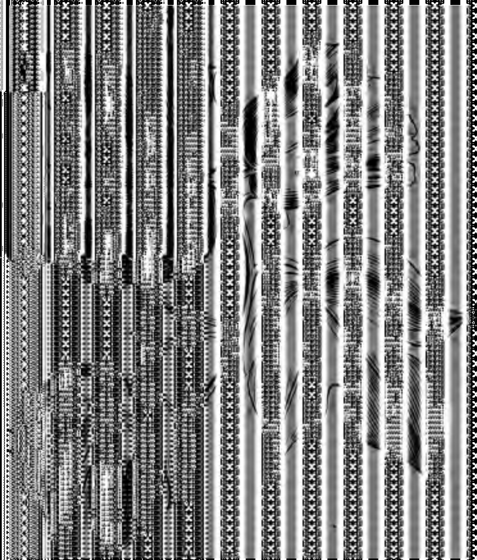
From the reign of Elizabeth the use of silk extended in England, as did likewise the means and machinery for manufacturing it. Down to the year 1718, however, the English weavers had to depend upon Italian workmen for a supply of the spun silk on which they were to work; but in that year, Mr. Lombe, of Derby, went to Italy, and, in the disguise of a common workman, succeeded in taking accurate drawings of the silk machinery there in use. On his return to England, he erected an extensive silk-mill on the river Derwent, at Derby, and obtained a patent for the sole and exclusive property in the products of it for fifteen years. His mill contained 26,586 wheels, and 97,746 movements, which worked 73,726 yards of silk thread with every revolution of the water-wheel by which the machinery was moved; and as this revolved three times in each minute, the enormous quantity of 318,504,960 yards of silk thread could be produced daily. The building wherein this machinery was erected was of great extent, being five stories in height, and occupying one-eighth of a mile in length; it was situated on a small island in the Derwent; and there it remains to the present day, an interesting memorial in the history of the silk-trade. So long a time was consumed in the erection of the machinery, that the remainder of the term granted was insufficient to remunerate the inventor for his labours. He therefore applied to parliament for an extension of his patent. This was not

granted; but in lieu of it parliament purchased the patent of his invention for 14,000*l*. for the benefit of the public; the conditions being, that competent persons should be allowed to execute an exact model of the machinery, to be deposited in such place as his majesty should appoint, in order to diffuse and perpetuate the manufacture.

The encouragement thus given to the silk manufacture in England greatly accelerated its progress; and from that time may be traced a continuous train of important improvements in the different branches of the manufacture; so that at present there are but few countries in Europe in which the silk manufacture is not to some extent carried on; although the rearing of the silk-worm has not been attended with so much success in the northern as in the southern countries of Europe.

Other materials employed in dress are of much less importance. Among these, *leather*, perhaps, holds the highest rank. *Furs*, dressed in various ways, *felted* wool for hats, *feathers* (used, not for warmth, but for decoration), and a small quantity of *metal* for buttons, buckles, and other minor articles, are the principal materials employed, besides those already noticed.

The reader will, therefore, be prepared to expect that a popular account of those arts the great object of which is the production of clothing, should treat chiefly of those relating to *woven* materials. We shall, therefore, proceed to the consideration of the *cotton*, *woollen*, *linen*, and *silk* manufactures, tracing the raw material through the various states and processes to which it is subjected until it is ready for our use as an article of dress. After having completed this department of our subject, a short notice will be given of such other materials for clothing as seem, from their importance, to demand it.



green, and resemble in shape those of the sycamore. The flower is of a pale yellow, with a purple centre, resembling in its form that of the *Hybiscus*, or of the holyoak, and produces a three-celled, capsular fruit, which is supported by the three involucral leaves of the flower. When ripe, the pod becomes brown and hard, and finally bursts open, disclosing in each cell a mass of white, soft, fibrous matter, enveloping a number of seeds, about as large as those of our common lupin. The pod attains the size of a large walnut before it opens; and the fibrous material which it thus discloses, is *cotton*.

The other principal species are shrubby, biennial, or perennial plants. 1st. The *Gossypium Indicum*, a shrub growing ten or twelve feet high, a native of the same hot countries as the former. It is biennial or perennial, according to the climate, and when cultivated in colder countries, becomes only an annual; but it is a distinct species from the G. *herbaceum* above mentioned, differing in the form both of its leaf and fruit. 2nd. The G. *hirsutum*, a shrub indigenous in Central America. 3rd. The G. *religiosum*, a native of Africa and America, as well as of India: the flower changes from white to red. 4th. The G. *arboreum*, as its name imports, attains a larger size, being from twelve to twenty feet high: it is a native of all the intertropical countries; but as its produce is not equal in quality to that of the foregoing species, it is but little cultivated. There is a tree called the *silk-cotton tree*, which belongs to a sub-order called *Bombaceæ*. This tree is one of the largest and finest in the world: its botanical name is *Bombax ceiba;* but it is familiarly known as the *umbrella-tree*, from its spreading head. It produces a large pod, containing a brown, extremely soft, silky cotton, which unfortunately does not admit of being spun, as the common cotton is, and is therefore only used for stuffing cushions, &c.

There are other species of the cotton-tree; but as the G. *herbaceum* is the most valuable source of cotton, we will confine our attention to it. All its varieties require a dry, sandy soil, and will grow where the ground is too poor to produce any other crop. It is impatient of much wet, and the harvest is often destroyed by a rainy season: nevertheless, the plant usually flourishes best near the sea-side. The finest, and that most esteemed in commerce, is the production of the low sandy islands and plains near the coasts of South Carolina and Georgia: hence this cotton is called *sea-island;* and it is said to owe its superiority to the action of the salt spray on the plant, and to the use of salt mud from the marshes as manure during its growth.

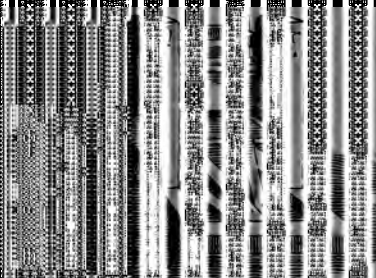
For cultivating the cotton tree, the fields are ploughed into ridges, about five feet apart. The seed is sown in drills along the tops of the ridges; and when they come up, the plants are thinned out, so as to leave the healthiest and strongest at sufficient distances apart. Repeated hoeings and weedings take place, the earth being drawn up round the stems of the plants, not only to supply the roots with nourishment, but also to support the plant against the violent winds and rains of a tropical climate. The plants are also liable to the ravages of a caterpillar, which will often totally destroy the crop. If the cotton escape these dangers, and the season be favourable, the produce is ready for gathering in five or six months. On an average, four acres yield about five hundred-weight of clean cotton, separated from the seeds.

In harvesting the cotton, it is in some countries the practice to gather the whole pod; but as the husk is brittle, the fragments become mixed up with the fibre, and greatly increase the difficulty of cleaning the cotton, which is one of the most troublesome processes in the manufacture. Accordingly, in those districts where more care is paid to the cultivation, the cotton and seeds are drawn out of the pod, the husk being left behind; this is, of course, not done till the pod has opened naturally; and since they do not all open at the same time, the harvest lasts several weeks. The cotton is gathered in the morning, to avoid the action of the sun on the fibre, by which it would be discoloured; and none is gathered in wet weather; since the moisture would produce mouldiness.

The cotton, as it is plucked from the pod, is put into a bag, suspended from the gatherer's neck; and from thence into a large basket. On the following morning it is spread out on wooden platforms to dry; and the time required for drying varies according as the cotton has been gathered in fine or damp weather; but as winds or exposure to the sun injure the fibre, the cotton is left no longer than is necessary to prevent its heating and fermenting when packed.

Preparations for Exportation.

When the cotton is dry, it is *whipped*, that is, it is suffered to drop through a hopper, or funnel, into a cylinder made of reeds, battens, or wire, supported in a sloping direction; and an axis carrying short arms nearly touching the cylinder, is made to rotate within the cylinder, either by a handle, or by machinery. The cotton, as it passes down



bottom of the hopper into a trough beneath. The fibres carried through by the saw are separated again from it by the brushes on the second cylinder, and, being swept off by these, drop into a box at the bottom of the gin.

The cotton, when cleaned by any one of these processes, is next to be packed for exportation. In order to economise ship-room, it is reduced in bulk by being subjected to an enormous pressure. Several square frames are piled up so as to form a deep chest, the separate parts being kept in their places by iron bolts at the corners. This chest is erected on the board of a powerful hydrostatic press; and there are grooves cut in the board, in which ropes are previously laid, to tie up the cotton when pressed into a bale. The top board of the press enters into the top of the case after this has been filled with cotton, hard rammed down. The press, by its enormous power, reduces the bulk of the cotton; and as the lower board in succession passes upwards through each case, that case is removed, till the bale is reduced to its smallest limit. The rope is then tied round the bale, and it is put into a bag.

The bulk of the cotton is so reduced by this pressure, that a weight of from five to six hundred-weight occupies only about twelve cubic feet. The average gross weight of a bag of cotton from the United States is about three hundred and forty pounds, of which the bag weighs seven.

Cleaning and Spinning.

Having thus conducted the reader through the various processes by which the cotton is transferred from a vegetable product to a woolly material compressed tightly in a bag, we will proceed to detail the processes through which it passes after its arrival in England.

Liverpool and Manchester are the two great towns which owe their distinction and their wealth mainly to the cotton manufacture—Liverpool, as the port where nearly all the cotton is landed, and Manchester as the town where it is either manufactured into cloth, or where the manufacturers have established their common market. There are of course other ports and other manufacturing towns concerned in this important branch of national industry; but it will be sufficient to name Liverpool and Manchester as the two principal. There are probably no two towns in England more dependent on each other than these. The Manchester manufacturer depends on the Liverpool merchant for the requisite supply of cotton to enable him to com-

mence his labours; and looks likewise to the same party as the medium through whom the manufactured cloth will find its way to foreign markets. On the other hand, the Liverpool merchant looks to Manchester as the customer who will purchase the raw cotton which has been imported, and who will subsequently employ him as the agent to ship the manufactured goods to foreign parts.

This peculiar connexion between these two great towns led to the establishment of a water-communication between them, by way of the river Mersey, during the last century, and also by way of the Bridgewater Canal; and within the last ten years, to a land-communication, of infinitely greater importance, by means of the Liverpool and Manchester Railway.

We will suppose, then, that a bale of cotton is landed at Liverpool, and forwarded by the railway to Manchester, where it passes into the manufacturer's hands. If the cotton had not been compressed to the extent which we have described, the fibres would be sufficiently open for the future proceedings of the manufacturer; but they have become clotted and entangled by the pressure; and the cotton is also much contaminated with seeds, dirt, &c. These defects are removed by the processes of *cleaning* and *picking*. Formerly the cotton wool was spread out on a wire-work table, and beaten with sticks, by which the fibres were loosened from one another, while at the same time, small stones, twigs, dust, and other impurities fell through the meshes of the table. But this mode was necessarily a slow one, and, like most other parts of the cotton manufacture, has been superseded by machinery. An engine called a *willow* is now used for this purpose. It is a hollow wire-work machine, into which the cotton wool is placed, and which, by a rapid rotation, brings the wool into contact with spikes contained within it; the effect of which is, that the knots of cotton are disentangled, and solid impurities discharged through the meshes of the machine.

The cotton is now in a state to undergo the processes of *batting* and *blowing*. The object of these is still further to loosen the filaments of cotton, to arrange them in something like a regular manner, and to blow away the loose dust and small filaments. The willowed cotton is spread, in a thin layer, on an elastic apron, and is then beaten with great rapidity, by bars moved by machinery. The cotton thus becomes reduced to the form of fleecy layers called *laps*.

But the fibres have not yet acquired that regularity which the operations of the spinner require: they have to undergo the process of *carding*. Let any one consider the common operation of combing the hair, and he will have an idea of the principle on which carding is performed. Iron wires are fixed into a frame, and arranged with great regularity, at distances of about one-twentieth of an inch asunder. The frame, which is of leather, is wrapped round the surface of a large cylinder, which has then an appearance that may be termed that of a circular brush. Now suppose there are two such cylinders, covered on their surfaces with this bristly arrangement of iron wires, and revolving nearly in contact with each other, and in opposite directions; if a thin lap or layer of cotton be introduced between the two cylinders, and they be set into rotation, what will result? The teeth of one cylinder will tend to tear in one direction, and those of the other in a contrary direction: the consequence of which is, that any knots still remaining in the cotton are disentangled, and the fibres are forced to assume a perfectly parallel direction, between the teeth of the carding cylinder. Not only are the fibres thus symmetrically arranged, but the fleece or lap of cotton becomes greatly reduced in thickness, so as to form a sort of ribbon of parallel untwisted fibres. In some modern engines, a lap or layer, weighing about five pounds, and measuring thirty-two feet in length, is made to pass through all the parts of a complicated carding-machine in about fifteen minutes, and comes out in the form of a smooth ribbon 540 feet in length.

The following figures represent two cards to be used by hand: BC and A are the cards, to which bent teeth are attached; and D and E are the handles. When cotton is laid on the lower card, and the upper one is moved in the direction of the arrow, it will, by the action of the machine in which the wires all incline in one direction, be combed out and disentangled; but, in the machine in which the wires of the two combs are bent in opposite directions, it will be all swept off from the lower comb.

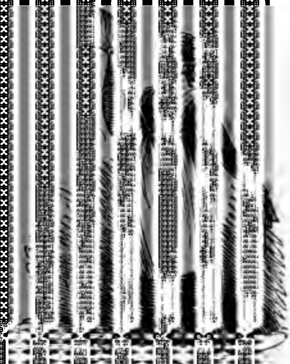
The cards, as the wires are called, were originally fixed to flat surfaces; but successive improvements have led to the adoption of cylindrical machines of a most elaborate construction, in which the cotton is drawn in between two cylinders—partially disentangled by them, transferred to another cylinder, and farther disentangled, successively passed between two or three more cylinders, flattened, thinned, smoothed, and finally thrown off as a ribbon of

happens that a fibre gets doubled or bent in the middle round one of the wires. To unbend this doubling, to make still more complete the parallelizing process, and to condense the ribbon into a more solid form, are the objects of drawing. The ribbon, or *sliver*, as it is called, is drawn successively between two or three pairs of rollers, of which one revolves faster than the other; the effect of which is, that the ribbon is dragged or elongated by the roller which revolves fastest. A great many ribbons are laid one on another, and drawn through the rollers at the same time, by which it is found that the fibres are more completely straightened than if one ribbon were only acted on at a time.

The cotton comes from the drawing machine in the form of nearly cylindrical rolls; and it has next to go through the process of *roving*. This consists in winding it round pieces of wood called *bobbins*, and at the same time giving it a slight degree of twist. Sir Richard Arkwright first effected this process by letting the rolls of cotton fall into a cylindrical can, which was rotating on a vertical axis: by this motion the cotton arranged itself round the side of the can, and became slightly twisted at the same time; after which it was carefully wound by hand round wooden bobbins. But by successive stages of improvement, the whole of these effects are brought about in a more perfect manner by means of a complicated machine called *the bobbin-and-fly frame*. There is another machine employed for this purpose, called the *tube-roving machine*, in which a similar effect is brought about by very different means.

The various processes now detailed have ended in winding the cotton, or, as it is now called, the *roving*, round sticks called *bobbins;* and we proceed to describe the way in which the bobbins, with their loads, are used. The preceding processes are called collectively the *preparation* of the cotton: the next belongs to the *spinning* the cotton into thread.

The rovings are stretched and made finer and thinner by means of a machine called a *stretching-frame*, and then come out as a very soft kind of roving, which must be handled with great delicacy. The principle on which the stretching is effected may be seen from the annexed cut. If these four rollers revolve on their axes, and the cotton be drawn between them, it will merely be flattened, provided the rollers *revolve with equal velocity;* but if C and D revolve faster than A and B, the cotton roving will be drawn out and greatly elongated. It was this principle that led to such beautiful results in Arkwright's invention.



thread: it is handed over, in the form of yarn, to the *weaver*, who proceeds to transform that which is now a bundle of thread-like fibres, into an extended piece of cloth from which garments may be made.

Weaving.

We now proceed to that part of the manufacture which consists in *weaving*. This is merely an interlacing of threads, crossing one another, so that those which proceed in one direction, help to fix those in the other, and *vice versa*. In a long piece of woven cloth, the long threads are collectively called the *warp*, and the cross-threads the *weft* or *woof*; the outer thread on each long edge is the *selvage*, where the weft-thread returns in its direction. Dr. Ure has observed, "The art of weaving is more ancient than that of spinning, for the first cloth was, no doubt, akin to what we call matting—a texture formed by the interlacement of woody fibres, and of grasses of various kinds, as is still executed by several of the South Sea Islanders. At the period of Captain Cook's voyages, most of them were strangers even to that rude art, for they made their cloth by cementing or sticking shreds together, rather than by any kind of decussation (network)."

Most kinds of calico, and other preparations from cotton, receive a stiffening quality by means of size or starch. This is imparted to the thread which forms the *warp*, before the process of weaving is commenced. The warp-yarn is first wound off from the bobbins on which it is left by the spinning-machine, and transferred to other bobbins of a larger size, from which it is again transferred to cylindrical rollers of a given length and shape; and from these it is by a third transference, wound on a large beam called the *roller* or the *warp-beam*, where it lies in parallel and extremely equal layers. The machinery by which the yarn is transferred to this beam also effects the sizing or dressing process, and is called the *power-loom dressing-machine*. The sizing is effected in an ingenious manner. While the threads are travelling from the rollers to the warp-beam, by the moving force of machinery, they pass between two rollers, the lower one of which is immersed in melted size, starch, paste, or whatever the stiffening substance may be. The threads, passing over the wetted surface of the roller, imbibe the paste from it, while the upper roller presses firmly on them, and squeezes out the superabundant liquid. In order that this may be done equally to every thread,

they are all spread out in one parallel layer, at equal distances from one another, each thread being separated from its neighbour by a pin or projection.

By one of those wonderful combinations of machinery which the ingenuity of our workmen so frequently presents, the same machine which wets the threads with paste, also dries them. The threads, after having been wetted, pass over a heated surface, which, aided by a powerful current of wind, artificially excited, completely dries the threads. The last operation of the machine is to wind the threads, sized and dried, round the warp-beam, which is done with the most undeviating regularity.

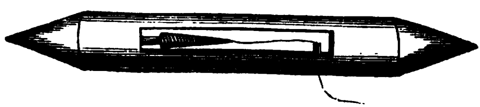
This which we have described is the improved mode of transferring the warp to the warp-beam. There are many other modes which were used in the infancy of the manufacture, and as they are still used to a partial extent in the cotton manufacture, and to a still greater in that of silk, we shall describe the most common method when treating of the latter material.

The process of weaving was for centuries performed by the help of a machine of moderate complexity, called a *loom*, which assisted the weaver in keeping the threads of the *warp* in a proper position, while he made the cross-threads or weft. But the last thirty years have witnessed the progressive exertion of mechanicians to produce a machine which shall not only keep the warp in a proper position, but shall also form the weft. This has been effected, and the *power-loom* of the present day presents a striking instance of automatic or self-acting machinery. We cannot here convey an adequate idea of this machine; but, by describing the action of the common hand-loom, which preceded the use of the power-loom, the nature of the process of weaving will be better understood.

The hand weaver does not receive his warp wound round a warp-beam, as effected by the dressing-machine: that is for the use of the *power*-loom. The common weaver receives his warp in a large bundle or roll, and from thence he has to transfer it to his warp-beam, or loom-beam. The threads have to be wound on the beam in a perfectly regular and equidistant manner; he therefore passes each thread between two teeth of a sort of comb, and fastens one end of the thread to his beam. By winding the beam he covers its surface with the threads, arranged equidistantly. The other ends of the threads are fastened to another beam at some feet distance, and by being well stretched out, there is formed a kind of sheet of parallel threads, almost resembling a cloth, were it not that there are yet no cross-

threads. To insert these cross-threads is now the weaver's business: every thread in passing from one beam to the other, goes through an eye or loop in a string which is fixed in an upright position. There is a separate string and loop to each thread; and all the threads are fixed to two frames, the first, third, fifth, &c., in order, to one frame, and the second, fourth, sixth, &c., to another. These frames, and the strings attached to them, are called *heddles*, and each heddle is drawn up and down by means of a treadle moved by the foot of the weaver; so that when one is drawn up and the other down, the adjacent threads of the warp are drawn in opposite directions, by which there is an opening left called the *shed*, into which the cross-threads or weft can be introduced. The use of all this contrivance may be illustrated by a very homely but sufficient comparison:—If we notice the manner in which stockings are usually *darned*, we see that a row of threads is arranged in the first place, in one direction: this forms the *warp*. The seamstress then works in the *weft*; but in order to do this, her needle has to be carried in a serpentine or crooked direction, over one thread, and under the next adjoining. But if, by any contrivance, she could manage to elevate the alternate threads of the warp and depress the others, she could pass the needle through in a straight line, without having to make the crooked motion of which we speak. Now it is to produce a precisely similar effect that the heddles and treadles of the weaver are employed.

An opening having been made by which the weft can be worked in, the weaver proceeds to do so. The weft is coiled round a little reel or roller called a *pirn*, and this pirn is fixed in an instrument called a *shuttle*, which has a smooth curved bottom, and which may be regarded as a sort of a *boat* for conveying the pirn across the threads of the warp. The following figure represents the shuttle, with the pirn



carrying the yarn or weft. The weaver introduces the shuttle between the threads of his warp, and pushes it from one side or edge to the other. In its progress, the weft yarn unwinds from the pirn, and leaves one thread of weft crossing all the threads of the warp. This being done, there is a vibrating beam or frame employed to drive up this weft

thread to its proper place, and into a square and regular direction. The thread is then made to double or turn round the outer thread or *selvage* of the warp, and is thrown by the weaver back again in the opposite direction, across the warp, by which a second weft thread is inserted; and this second thread is driven up close to the former by the beam or frame called the *batten*. Thus the weaver proceeds, thread after thread, throwing the shuttle from right to left with his right hand,—catching it with his left hand, and throwing it back again towards the right,—driving up each thread of weft before he inserts another, and lifting up the heddles alternately, so that one set of threads of the warp shall be uppermost at one moment, and the other at the following moment. The relative positions of the warp threads must obviously be changed after each use of the heddles, in order to produce that interlacing of threads which constitutes cloth.

As the weaver proceeds, laying thread after thread of the weft, he winds up the woven cloth on the beam nearest to him, and unwinds more warp from the remote beam.

Such a process as we have here described will produce a uniform texture, such as common calico, &c. But if any figure, pattern, or device whatever is required, a more complicated arrangement is necessary. If a series of stripes, running from end to end of the piece of cloth, be required, the warp must be made to consist of alternate coloured threads, and the weft be woven in between them in the common way. If stripes are to be carried the cross way of the cloth, the warp must be of one uniform colour, but the weft consisting of different colours, each colour having a different shuttle to itself. But if any complication of colours is required, or if any device such as we see in damasks and similar fabrics is wanted, a great increase of difficulty ensues; warp and weft of different colours, or of different thicknesses or sizes are required. An increased number of heddles are necessary, so as to open the threads of the warp in various ways for the reception of the weft, and a great number of shuttles are also necessary. By the combination of differently coloured warp-threads, differently coloured weft-threads, and a number of different heddles, almost any required pattern may be produced by the loom.

There is a peculiar kind of weaving called *tweel* or *twill*, and another called *gauze*, which are independent of the particular kind of yarn used by the weaver: they have a peculiarity depending on the way in which the threads interlace. If we examine a piece of common calico, we see

When the patterns of damasks, spotted muslins, &c., become too elaborate for the power of the common loom, a machine called the *draw-loom* is employed in their manufacture; and, within the last few years, a very beautiful machine, called the *Jacquard machine*, has been introduced for a similar purpose: but these machines, like the power-loom, are too elaborate to admit of detailed description here.

We have confined our notice of weaving principally to those parts which relate to plain fabrics such as calico. But, by various changes in the mode of combining the weft with the warp, together with various thicknesses and strength of yarn, a vast variety of fabrics are woven from cotton, such as cambric, muslin, damask, diaper, cotton-velvet, velveteen, corduroy, fustian, cantoon, moleskin, &c. All these furnish us with notable examples of what can be done when the fibres of cotton have once been made, through the labour of the spinner, to assume the form of thread or yarn. The difference between the fabrics just named is so great that we can scarcely believe them to be made from the same material, until we reflect on the almost illimitable power which the loom has of altering the mode in which the threads are made to interlace. We may observe, that in many of these cotton fabrics, the threads are, after having been woven, worked up into a sort of *nap*, and the fibres *cut*, by which a hairy texture is produced. It is by a process somewhat similar to this that the beautifully soft surface of velvet—whatever may be the material—is produced. If we examine the back of a piece of velvet, we see the usual threads as produced by weaving; but the front surface, or face, has that delicate softness which is so remarkable as to have given birth to a well-understood word, "velvety," in our language, and which is produced by a working up and cutting of the fibres of the material.

A remarkable and extensive employment of cotton thread has for some years been in the manufacture of *bobbin-net*, and a variety of fabrics more or less resembling lace. These used to be made on a small scale by the cottagers of most parts of England, and were called *pillow lace*, from the modes in which they were made. But machinery is now employed for this purpose, to an enormous extent. We are aware how tiresome are repeated descriptions of intricate machinery; and shall therefore content ourselves with saying that bobbin-net and other kinds of lace-like fabrics are made by a species of weaving suited to the peculiar manner in which the threads interlace among one another.

Bleaching.

Cotton, flax, wool, and silk, have all, in their natural states, a certain shade of colour. These tints remain with them more or less during the processes of weaving; so that if it be desired to produce them in a perfectly *white* form, it is necessary to subject them to some bleaching process. Bleaching, it must be borne in mind, is not imparting a colour to cloth, but removing all colour from it.

The Egyptians and other ancient nations appear to have known certain modes of bleaching linen cloth; but their processes, as well as those of later ages, are very well known to us. Until about a century ago, bleaching was hardly known in England, either in theory or in practice. The brown linens made in Great Britain were sent to Holland to be bleached. This process consumed the long period, namely, from March to October of each year. The principal Dutch bleaching-grounds were in the neighbourhood of Haarlem; and the great success of their bleaching was ascribed to the superior efficacy of the water, which was filtered sea-water. The process consisted in steeping the linen for about a week in a potash ley poured over it boiling hot. The cloth was then taken out of the ley, washed, and put into wooden vessels containing butter-milk, in which it lay under pressure for five or six days; after this it was spread upon the grass, and kept wet for several months, exposed to the sunshine of summer.

In 1749, an Irishman introduced a somewhat similar mode of bleaching into England, and after many difficulties, succeeded in effecting it tolerably well, but with lamentable slowness. From this time a succession of improvements took place. Dr. F. Home showed that that part of the effect which milk produced in six or eight weeks, might be produced by weak sulphuric acid in twenty-four hours. This enabled the manufacturer to receive his bleached goods in a much shorter time than before, and therefore to trade with less capital.

The next important, and in fact we may say *the* important improvement in the art of bleaching, resulted from the discovery of *chlorine*. This gas was first separated from muriatic acid by Scheele and Berthollet about the year 1780; and one of the first properties discovered in the new gas was an extraordinary power of destroying vegetable colour. This fact was soon taken up by Saussure, James Watt, Professor Copland, Mr. Henry, and other practical men, and a speedy revolution took place in the art of bleach-

ing. There were, however, sundry objections made to the use of chlorine, on account of the offensive smell which it exhales. But it was discovered that the gas might be united with lime, whereby much of the odour was removed, without depriving the gas of its bleaching property. As a proof of the wonderful advance made in this art, Dr. Ure states, that an eminent bleacher in Lancashire once received 1400 pieces of gray muslin on a Tuesday which, on the Thursday immediately following, were returned *bleached* to the manufacturers, at the distance of sixteen miles, and they were packed up and sent off on that very day to a foreign market: thus effecting in two days what formerly occupied six months! We will now describe the present mode of bleaching cotton fabrics.

When the woven cotton passes to the bleacher, he has the pieces sewn up end to end into a longer piece 500 yards in length, and stamps the owner's name on one end of each piece, which is done in a kind of ink formed of coal-tar. The cloth is then drawn rapidly over a hot iron, by which the hairy filaments of cotton are singed off without burning the cloth itself. The pieces of cloth are next folded up into an irregular bundle, and thrown into a large cistern of cold water, where they become completely soaked. When quite wetted, the cloth is put into a revolving hollow cylinder, by which it undergoes a process of washing: this prepares it for the reception of the bleaching materials.

A solution of lime is then prepared, by slaking quicklime, and mixing it into a kind of cream with water: this cream is laid between the folds of a long piece of the cloth, and the whole is placed in a boiler, and boiled rapidly for several hours. This removes the paste which the cotton had received before being woven, and also the greasy spots which are likely to occur in the cloth.

The cloth is now prepared to receive the *bleaching-powder*. This is a *chloride of lime,* and is made on a great scale in manufactories devoted to that express purpose. To produce it, a quantity of slaked lime is spread out on a stone floor, and the apartment closed in perfectly air-tight. A leaden pipe leads from it to a large leaden vessel, containing common table salt, black oxide of manganese, and dilute sulphuric acid. A chemical action takes place among these ingredients, especially when aided by heat; and the chlorine gas (one ingredient in common salt), becoming liberated, ascends through the leaden pipe, and unites chemically with the lime spread out on the floor. This, then, is the *bleaching-powder;* and in order to apply it to

the cloth, 24lbs. are dissolved in 60 gallons of water, or, if the quantity of cloth to be bleached be 700lbs., 388lbs. of bleaching powder are dissolved in 971 gallons of water. In this cold solution the cloth is steeped for about six hours; and on taking it out and washing it with water, it is found to be *partially* bleached.

The bleaching is farther extended by steeping the cloth for a few hours in water containing a little sulphuric acid: this removes the oxide of iron which the cloth is apt to contain, and also the small portion of lime which is liable to adhere to it. The cloth is again washed in cold water, and then boiled for a still longer time in a solution of caustic soda. The cloth is again washed in clean water, and again steeped for five or six hours in a solution of bleaching-powder, weaker than the first. Lastly, another steeping for four hours in water slightly impregnated with sulphuric acid, presents the cotton cloth in a purely white state. It will thus be seen that the cloth, even under the improved process, undergoes rather a complicated treatment; but if it be of inferior or cheaper quality, some of the above processes are omitted.

But the labours of the bleacher are not yet ended; there are many *finishing* processes still to be done. When the last bleaching is ended, the cloth is carefully washed, to remove all traces of the acid, &c. It is then *squeezed*, to force out as much as possible of the water remaining in the cloth: this squeezing being effected by passing the cloth between two rollers working closely on each other. The cloth is now damp and much crumpled; and the next process is to pull out each piece to its full breadth: this is done by women. But the edges of the piece still continue folded in. To make them straight, a workman strikes the bundle against a smooth beating stock, first one edge and then the other. By this process the pieces are spread out to their full breadth, and all the folds and wrinkles removed.

The cloth is then *mangled* while wet: this is done by passing it between rollers, by which it is made tolerably smooth and even, and ready for *starching* or *stiffening*. The starch employed for this purpose is made from flour with the addition of a small quantity of some earthy substance. It is mixed into a thick paste, and poured into a box or vat. The cloth is made to dip into this vat, and thus imbibe a portion of starch, and immediately afterwards to pass between two rollers, which expel the superfluous starch, and work the remainder well into the pores of the cloth, by which it becomes thickened. It has been observed,

"This method of thickening was undoubtedly intended at first as a fraudulent method of making the purchaser believe that the cloth was much stouter and thicker than it really was. But it has been so long practised, and is now so universally known, that all purchasers must be aware of it, and of course not in any danger of being deceived. But it certainly serves the purpose of making the goods appear much more beautiful, and of a stouter fabric to the eye; and as long as they continue unwashed, they are really stronger than they would be without this artificial dressing. So far it is beneficial; and as it does not enhance the price, the purchasers have no reason to complain of imposition."

The starched cloth is hung up in a heated room to dry; and is then ready for *calendering*, or imparting a smoothness and gloss to it. For this purpose it is damped by being slightly sprinkled with water by an ingenious machine, and is then forced between two rollers, which press it very heavily. Different appearances, varying from that of a soft silky lustre to that of wiry texture, are given to it by varying the degree of pressure. The cloth is now finished, and is folded into a pile, with pasteboard and iron plates between the folds, and subjected to a heavy pressure, in a Bramah press. When removed from this press, the cloth is refolded, and consigned to the respective owners.

Thus we see that the process of bleaching a piece of cotton involves more than twenty distinct processes; and yet the charge for the whole is less than one halfpenny per yard! Such is the effect of combined improvements in mechanical and chemical processes; improvements which give to the large bleach-works of Lancashire an interest felt both by the man of science and the intelligent observer who looks only to learn.

Dyeing.

In giving a brief account of the process of dyeing cottons, we may remark (and most persons are probably more or less aware of the fact), that cottons are never seen with such brilliant colours as sometimes adorn silk or woollen fabrics. On this subject a modern writer observes, "With respect to the aptitude of being dyed, and the brilliancy of the colours thus communicated, there is found to be very great difference in different tissues. Animal substances are much more easily dyed than vegetable substances. Of animal substances, *silk* receives colour more readily, and the shades given are brighter and more beautiful than those which can be imbibed by any other tissue. Woollen cloth is also very fit for being dyed, and receives very brilliant colours with avidity, though in this respect it is inferior to silk. Cotton and linen are much more difficult to dye, and cannot be made to imbibe such brilliant colours as silk or woollen. Thus the rich scarlet given to cloth by the combined action of cochineal and the oxide of tin, has never been communicated to cotton cloth or linen. The Turkey-red dye, which is by far the finest and most permanent red that has ever been communicated to cotton cloth, is a crimson, or rather a crimson with a shade of brown: it has not the least approach to a scarlet. Upon what this difference between animal and vegetable bodies in the capacity of receiving colours depends, we do not know. Both woollen and silk contain a notable quantity of nitrogen among their constituents, while this principle is altogether wanting in cotton and linen. How far the property of easy dyeing depends upon the presence of nitrogen, it is impossible to say; but it is the only chemical difference in their constitution that can in the present state of our knowledge be pointed out."

When cottons are to receive the Turkey-red dye, it is preferred to have them unbleached, as the natural colour of the material is found to facilitate the reception of the dye; but we believe that in other instances it is customary to have the fabric previously bleached. The woven material is first boiled for two hours in sour water, or in an alkaline ley, or in some other liquor found to answer the required purpose, and then rinsed in clear water. It is afterwards steeped for some time in water containing a small quantity of sulphuric acid, again rinsed in clear water, and dried. By these processes, the small quantity of iron and of earthy matter contained in the cotton is removed.

The next process is that of *aluming*. Four ounces of alum to every pound of cloth are dissolved in water, and then mixed with a larger quantity of cold water; and a small quantity of soda or tartar is sometimes added. The threads are impregnated by working a portion of this solution into them, and the whole of the remaining liquor is then thrown upon the cloth, and left for twenty-four hours. The cloth being removed to a stream of water, a portion of the alum is washed out, but the greater part remains in the cloth, and acts as a *mordant* or agent, by which the cloth is enabled to retain the dye.

Another process, preparatory to dyeing, is that of *galling*. Powdered galls are boiled for two hours in water, the proportions of the ingredients being regulated by the strength of the galls, the effect to be produced, and the quantity of cloth. The solution of galls, being reduced to a moderate temperature, is poured upon the cloth, and left for twenty-four hours, if the dye is to be black; but for other colours, from twelve to eighteen hours are sufficient. The cloth is then wrung out and dried.

These processes are intended to prepare the cotton for the reception of the dye. The dyeing itself is a routine of operations depending in great measure on the colour which is to be imparted to the cloth; some colours being more easily worked into a solution than others, and some being made, more easily than others, to combine with the cloth. It is impossible, therefore, in our brief space, to detail the modes of imparting all the various colours to cotton cloth. We will take *blue* as an example, which will serve to convey a general idea of all.

One process recommended for dyeing cotton blue, is the following:—From six to eight pounds of indigo, reduced to powder, are boiled in a ley drawn off from a quantity of lime, equal in weight to the indigo, and a quantity of potash double its weight. During the boiling, which is to be continued until the indigo is completely penetrated with the ley, the solution must be constantly stirred, to prevent the indigo from being injured by adhering to the bottom of the vessel. During this process, another quantity of quick-lime, equal in weight to the indigo, is to be slaked. Twenty quarts of warm water are added, in which is to be dissolved a quantity of sulphate of iron, equal to twice the weight of the lime. The solution being completed, it is poured into a vat capable of containing one hundred and twenty gallons, half filled with water. To this the solution of indigo is added, with that part of the ley which was not employed in the boiling. The vat must now be filled up

to within two or three inches of the top. It must be raked twice or thrice a day till it is completely prepared, which is generally the case in forty-eight hours, and sometimes sooner.

Thus is prepared what is called a *blue vat*, that is, a vessel full of a mixed liquid capable of imparting a blue dye. There are numerous other modes of preparing a blue vat, but we need not detail them. It is usual to dip the cloth first into a faintly coloured vat, and afterwards in one of deeper tint, and so on until the required tint is obtained. Five or six minutes is a sufficient time for the cloth to remain in each vat or bath, as it will absorb, in that time, all the colouring matter which it is capable of receiving.

In order that the colours thus employed may adhere firmly to the cloth, it is generally necessary that a *mordant* should be employed. *Mordant* is a name given to any substance which will combine with the fibres of cotton or other material, and will also combine with the colouring substance; so that the mordant being first applied, the fibres become closely united to it, and the colouring matter being next applied, becomes, in its turn, closely united to the mordant, and all three adhere closely together. This is the principal feature in the theory of dyeing. Alum, tin, lead, copper, and galls, are the principal substances employed as mordants; and when any one of them is required, it is applied to the cloth previous to the dye, by such processes as we have described as *aluming* and *galling*.

The most difficult process in dyeing cotton, is to impart the beautiful rich red called *Turkey-red*. We will merely enumerate the successive processes, without attempting to enter into details. 1st. The cloth is steeped for twenty-four hours in a hot solution of potash, to remove impurities, &c. 2nd. It is boiled for some time in a ley of carbonate of soda. 3rd. It is passed through a trough containing a milky-coloured liquid, which has a soapy quality. 4th. It is dried either on the grass in the open air, or by a stove. The alternate dipping in the soapy liquor, and drying, are repeated three times. 5th. It is steeped in a weak solution of pearlash, and then hung out and dried. 6th. It is steeped in another soapy liquid, formed of different substances from that last alluded to: this is done three different times, and the cloth is dried after each steeping. 7th. It is again steeped in a ley of potash and soda, drained, washed, and dried. 8th. It is now *galled*, in a manner similar to that before detailed. 9th. The process of *aluming* now succeeds. 10th. Another drying and washing prepares it for, 11th. *Dyeing*: madder and bullock's blood are two

of the ingredients forming the dye into which the cloth is dipped. 12th. Madder contains a *brown* as well as a *red* colouring matter: the brown is now removed by boiling the cloth for several hours in a solution of soda, soap, and pearlash. 13th. The tint of red is brightened by boiling the cloth under pressure at a very high temperature, in water containing soap and protochloride of tin. 14th. The cloth is now finished by spreading it out on the grass, and exposing it for a few days to the sun.

So complicated are the processes here detailed, that some eminent firms confine themselves almost exclusively to dyeing cotton fabrics of a Turkey-red colour, and have many acres of fine grassy turf on which the dyeing or *grassing* is effected. This process, we may here remark, is something more than a mere drying; it is a kind of oxidation, the oxygen of the atmosphere exerting a peculiar effect on the chemical ingredients previously employed.

As we shall have to allude again to some of these processes and colouring materials, when we come to speak of dyeing other woven fabrics, it will not be necessary to extend the subject in this place.

Calico Printing.

Calico printing has been defined as "the art of communicating different colours to particular parts of the surface of cotton or linen cloth, while the rest of the cloth retains its white colour; or the whole of the cloth may be dyed one colour, as *red* or *blue*, except particular parts, to which some other colours, as yellow, orange, green, &c., are given."

The principal processes are *singeing*, *bleaching*, *calendering*, *printing*, *stoving*, *dyeing*, and *brightening*. The first three of these have been briefly described under the head of "Bleaching;" we therefore pass on to notice the art of calico *printing*. This is effected by *block-printing*, by *press-printing*, or by *cylinder-printing*. In the first, the figure intended to be imparted to the cloth is cut out upon a block of sycamore measuring about twelve inches by seven, the parts which are to make the impression being left prominent, and the rest of the block cut away, as is the case in wood-engravings, or in blocks for paper-hangings. When the figure is too complicated, and the lines are too fine to admit of being cut in wood, the device is made by means of small pieces of copper, which are very ingeniously driven into the block, and the intervals filled

up with felt. The preparation of these blocks is an art which commands high wages.

The *press-printing* is a more recent process, and one of great beauty. Supposing the device to be five colours, there are five plates prepared, each measuring about thirty inches by five. They are cast in a kind of stereotype-metal, and each has in *relief* the device which is to be printed in one colour. All these plates are fixed side by side on a well-seasoned block of wood, so that all may be made to imprint the cloth at one time. At one end of the printing-machine is a series of five troughs, containing five different colours; and a boy dips into these troughs a kind of brush so formed as to take up a portion of colour from each. By an ingenious arrangement, five patches of colour are laid on in a wet coating on a flat cushion; and the block, with the face downwards, is made to descend upon this cushion, so that each stereotype plate takes up a coating of one particular colour, without interfering with the adjoining colours. The block next descends upon the cloth, which is laid out smooth upon a sort of table, and imprints five colours upon it in five distinct and parallel plates, the length of each patch of colour being across the cloth. The cloth is then shifted onwards about five or six inches, so that when all the circle of proceedings shall have been again gone through, each second patch of colour will be a little in advance of the preceding patch of the same colour. At the third adjustment, a farther advance will have been made; and when the fourth and fifth impression have been made, a shifting having taken place before each, it is easy to see that some parts of the cloth have received the whole of their five colours, all adjusted to their proper places. The adjustment of the device on each plate, and the shifting effected by the machine, require very delicate and accurate arrangements.

Cylinder-printing is performed by means of a copper cylinder several feet long, upon which the different figures to be given to the cloth are engraved; and by its circular motion, the whole of these figures are impressed upon the cloth as it is moved under the cylinder. Another mode of cylinder-printing is to have the intended figures engraven upon a flat copper plate about a yard square. Upon this plate the colour to be applied is spread. It is then drawn through a machine in such a manner that an elastic steel plate, called a *doctor*, takes off all the colour except that which fills the engraving. It is then pressed against the white cloth, on which it thus leaves the impression of the engraving.

We have said that both *printing* and *dyeing* form portions of the same routine of operations. The way in which their combined action determines the ultimate colours of the cloth, is one of these four: viz. 1st. The printing process is applied to fixing *mordants* on the cloth, which is afterwards dyed in the common way, those parts only retaining the colour which have imbibed the mordant, while the other parts of the cloth may be washed white: 2nd. The printing is applied to cloth already dyed, in order to remove the colour from certain portions of it which are either intended to remain white, or to receive some other colour: 3rd. The printing is applied to cloth before it is dyed *blue*, in order to prevent the indigo from being fixed on those parts to which it is applied, that they may remain white, or be afterwards made to receive other colours: 4th. The printing is applied to communicate mordants and colouring-matter at once to the cloth.

The nature of mordants has been already explained: they are substances which enable the fibres of cotton, &c., to retain colouring-matter applied to them. The principal *mordants* employed by the calico printer are alum, oxide of tin, oxide of iron, and acetate of iron. There are also other substances called *dischargers*, *resist-pastes*, and *dyes*. The combination of colours on a piece of cloth is effected by two or more of the four processes of *printing*, *dyeing*, *resisting*, and *discharging*; and as we cannot detail all the various ways in which these are combined, we will select two or three examples.

Suppose a blue cotton with white spots be required. A device of spots is engraved on a plate, or cut in a block, and printed on the cloth by one of the methods already described. The ink or colour employed is a *resist-paste*, of which there are several kinds, consisting of various salts, gums, and earths. When the printing is dry, the cloth is dipped into a vat of blue dye, containing indigo, sulphate of iron, and one or two other ingredients. The fibres retain the indigo without the aid of a mordant; and after exposure to the air, a clear blue dye is imbedded in the cloth. But the spots which had been printed *resist* the retention of the indigo, through the chemical action of the resist-paste; so that a subsequent washing removes both the indigo and the resist-paste from those parts, and leaves them in the form of white spots.

The above is an instance in which no mordant was required to fix the colour on the cloth; but let us now select an instance in which the dye, however well effected, would

afterwards wash out, unless a mordant were previously employed. Suppose a red cotton with white spots be required. The dye-stuff usually employed for this colour is the vegetable substance called *madder;* and this requires, for its retention by the cloth, that the latter should be previously steeped in a mordant formed by a solution of alum. The spotted pattern is then printed, by means of a block, a plate, or a cylinder, on the mordant, with an ink formed of gum and *citric acid.* This acid combines with the alum in such a way as to loosen its hold upon the fibres. The printed cloth is then put into a vat containing madder and cold water, to which heat is gradually applied. The cloth is kept in constant motion till it has gained the requisite depth of shade, when it is taken out and washed. By a subsequent boiling in water containing either bran or soap, the alum, citric acid, and madder are all removed from the spots which had been printed, while the remaining parts are left of a clear red. By rinsing the cloth in a weak warm solution of bleaching-powder, the white spots are still more bleached.

Another mode of obtaining a red ground with white devices is as follows:—The cloth is dyed in the usual manner of a Turkey-red colour. The device is then printed on it with an ink or discharging liquid made of tartaric acid thickened with gum. The cloth is then passed through an aqueous solution of bleaching-powder. A chemical action ensues between the tartaric acid and the bleaching-powder, by which the chlorine is liberated, and immediately discharges all the red from the printed spots, thus leaving them white. The spots receive a fine yellow colour by a slight change in the process. The tartaric acid is mixed with oxide of lead before it is used in the printing; and the cloth, after being printed and passed through the bleaching liquid, is again passed through water impregnated with bichromate of potash: this imparts a beautiful yellow to the spots.

In the instances here introduced, we have supposed the ground of the cotton to be dyed, and the white to consist of mere spots. But in the greater number of instances, the ground is either white or coloured, and a device consisting of different colours is printed on it. This is effected by a very interesting process. Although the substance called *madder* produces a rich red dye when used with a certain mordant, it will produce a purple with a second, a black with a third, a lilac with a fourth, and other tints varying from pink to deep red, or from lilac to black, ac-

cording to the mordant employed. Suppose, therefore, a piece of cotton is to have a white ground, with a pattern of three colours, red, lilac, and purple. There are three sets of printing-blocks prepared, one for each colour; and each block is inked with a particular mordant, and stamped on the cloth. The cloth is then dyed with the madder; and a subsequent washing removes all the dye from the ground, and converts the three mordants into red, lilac, and purple dyes, which adhere firmly to the cloth. This process may be varied in a variety of ways, and with other dye-stuffs besides madder.

One of the most beautiful applications of the combined power of machinery and chemistry which the present age has exhibited, is the preparation of *Bandana handkerchiefs.*

The term *Bandana* is of Indian origin, and is applied to pocket handkerchiefs of a peculiar kind, both of silk and of cotton, made in India; they were much sought after throughout Europe—probably from the circumstance that nothing equal to them could be produced in Europe. The ground of the handkerchiefs was usually of red, blue, or purple; and the pattern almost always consisted of spots, either white or yellow. The colour of the handkerchiefs was uncommonly permanent and enduring.

The demand for these handkerchiefs being very general, British manufacturers were induced to try how far they could produce successful imitations of them in cotton, which might be sold at a very low price. The first attempts were very imperfect, being founded on the common mode of *printing* calicoes which has just been explained.

There are many reasons why this mode is wholly inadequate to the production of a good dye; and even with the aid of many improvements that have since taken place, both in dyeing and in calico printing, a good imitation of Bandana handkerchiefs could not possibly be produced by such means. The colours, particularly the red, were found to be far from durable as thus produced.

The introduction of chlorine into the manufactures, led the way to a different mode of attaining the desired end,—a mode as beautiful in a scientific point of view, as it is economical when considered commercially. The parties who contributed more or less to those improvements which led to the production of beautiful imitation Bandanas, were many; but the firm of Monteith and Co., at Glasgow, are most eminently connected with the subject. We shall now, therefore, describe the machinery and the processes by which these manufacturers produce handkerchiefs, of

which the colours are as glowing and durable, and the white spots as pure and finely outlined, as any of the productions of the East.

The first operation is to dye the piece of cotton of the required colour, and in the best manner.

Now the great principle by which the Bandanas are produced from the piece of red or blue cotton, is by *removing* the colour from certain round or square spots disposed in a pattern over the surface of the cotton. This can be done by the peculiar action of *chlorine*. If a solution of chloride of lime were to be dropped on the dyed cotton, the colour would be removed from that spot. The question is, therefore, how can the chlorine be so applied as to remove the colour from a regular series of spots, all symmetrical in shape and well ordered? This is effected by shielding the surface of the cloth with a piece of sheet lead, through which are cut a series of holes into which the chlorine solution can flow. These plates are prepared by laying a very smooth piece of sheet lead on a thicker piece of the same metal: a piece of drawing-paper is laid on the lead; the desired pattern is drawn on the paper; and a man cuts out both paper and lead by making perpendicular cuts quite through both of them into the lower sheet of lead. Perforations are made through the lower piece of lead, corresponding to those in the thin one, so that if a piece of dyed cloth were placed between them and powerfully pressed, and a chlorine solution were poured on the upper plate, it would pass into the holes in the upper plate,—through the cloth,—and out by the holes in the lower plate.

Now the object to be attained here is, to prevent the cloth, whether of one or more thicknesses, from being touched by the solution in any part except where the designed spots are to be. This can only be attained by intense pressure; for we know how soon a liquid will spread sideways among the fibres of a piece of cloth. There are many ways of producing this pressure; but the one that is found most available for the purpose is that of the hydrostatic press.

At Monteith's factory, the hydrostatic arrangement is contained in one room, called the machinery-room, and the presses, with the handkerchiefs, &c., are in another; and there is a communication between the two. Fourteen thicknesses of cloth are operated on at once; and there are sixteen different presses arranged in a row, occupying a space one hundred feet in length, so that two hundred

that of a pocket handkerchief. Fourteen pieces of cloth are laid quite flat and parallel, one on another, and rolled on a beam at the back of the press. From this beam sufficient cloth is drawn out to cover the lower plate and receive the chlorine liquor, and after having thus been operated on, it is drawn between the rollers seen a little above and in front of the lower plate E, and from thence falls into a cistern of water D, at the lower part of the press. Supposing a layer of handkerchiefs to be placed on the lower plate E, that plate has to be lifted up, in order to meet the upper plate. This is effected by opening a communication between the 8-inch cylinder of the hydrostatic press and a cylinder, C, beneath the lower plate. As the 8-inch cylinder is loaded with a weight of five tons, the cylinder C is driven up by the same power. But when it is driven up so far that the handkerchiefs lying on it meet the upper plate, then an enormous pressure is brought into action, to press the handkerchiefs tightly together. This pressure is produced by shutting off the communication with the 8-inch cylinder, and opening that with the 1-inch cylinder. The 1-inch cylinder is also loaded with a weight of five tons, and as the cylinder C is about eight inches in diameter, it can be proved, according to the laws of hydrostatic pressure, that the lower plate becomes pressed against the upper one with a force of 5 tons $\times$ $8^2 = 320$ tons $= 716{,}800$ lbs. By this intense pressure the handkerchiefs are held so tightly together, that any fluid passing down to them through the perforations in the upper plate, cannot spread laterally.

All is now ready for the admission of the aqueous chlorine. This is prepared in an adjoining room, and admitted to a small leaden cistern, A, at the side of each press, which is provided with graduated tubes, by which the quantity admitted at one time can be regulated according to the number of spots in the pattern of the handkerchief. The liquid is allowed to flow through a pipe into the upper part of the press (which is fixed): it then flows through the perforations in the plate B, through the fourteen thicknesses of handkerchiefs, removing from them the Turkey-red or other dye in its passage, and after passing through the perforations in E, finally leaves the press by pipes arranged for that purpose. The liquor is allowed to remain a few minutes to act on the cloth; after which it is drawn off, and clean water is allowed to pass through in a similar manner, to wash away the chlorine, otherwise, on relaxing the pressure, the outline of the figure discharged would become ragged.

So admirable are the arrangements, that four men are sufficient to manage the whole sixteen presses, and keep them all working at once. They first go from press to press, admitting the water from the 8-inch cylinder, by which the lower plate is raised; the layer of handkerchiefs in each press is arranged in its proper place; the powerful pressure is then put in operation to them all; the chlorine liquor is admitted; the cleansing water is admitted; the presses are again opened; the layer of handkerchiefs is drawn between the rollers, and another layer brought between the plates; and so on, taking all the presses in succession. No time is lost by this method, since a few minutes are required for the chlorine to act on the handkerchiefs in each press. When fourteen pieces are entirely finished, they are carried away to the washing and bleaching departments, where the lustre of both the white and the colours is considerably heightened. By the excellent arrangement of the sixteen presses, 1600 pieces, consisting of 12 yards each, equal to 19,200 yards, are converted into Bandanas in the space of ten hours, by the assistance of four workmen.

The reader will then understand that it is by such a mode as this that those red or blue handkerchiefs with white spots are produced, in which the threads of the material are so thoroughly acted on, that both sides of cloth present almost precisely analogous appearances. The cloth is first dyed all over; and the colour is then driven out from those parts which are to form the spots of the pattern.

In the middle of the last century, the cotton manufacture occupied a comparatively humble position in this country: while at the present day, *the exportation of manufactured cotton exceeds that of all our other manufactures put together*. The annual value of exported cotton amounts to about *eighteen millions sterling;* while the quantity retained for home consumption is valued at nearly as much. There are about fourteen hundred thousand persons dependant on the various branches of the manufacture; and the quantity of raw material imported, chiefly from the United States, is three hundred millions of pounds yearly!

Chapter III.

WOOL.

Nature and Production.

The manufacture of wool into a useful form may now engage our attention. This valuable production is transformed into *broad cloths*, *kerseymeres*, *baizes*, *flannels*, *worsted*, *stuffs*, *merinoes*, *carpets*, and a number of other well-known fabrics. Before the great advancement of our cotton-manufacture, that of wool was regarded as the distinguishing characteristic of British industry; but it has now been forced to yield to its powerful rival. Still it has shared in the prosperity which machinery has given to our manufactures generally, and it is, in every respect, an important branch of art. As an instance of the extreme rapidity with which steam-power machinery enables the various processes of a spinning and weaving factory to proceed, it has been stated, that the late Sir John Throgmorton once sat down to dinner dressed in a coat which on the same morning had been wool on the back of a sheep. The animals were sheared, the wool washed, carded, spun, and woven; the cloth was scoured, fulled, sheared, dyed, and dressed; and then, by the tailor's aid, made into a coat, between sun-rising and the hour of seven, when the party sat down to dinner with the chairman dressed in the product of this active day.

The fabrics prepared from wool are distinguished into two great classes—those which partake of the quality of *worsted*, and those which obtain the name of *cloth*; the former are made from long wool, and the latter from short. The *sheep* is the principal animal from which the wool is obtained; but the goat, and a few other animals, furnish a small supply in other countries. The long wool of a sheep, called *combing*-wool, is as much as eight or ten inches in length; and these long filaments are combed out unbroken, and spun into worsted; but the short or *clothing*-wool is not more than three or four inches long, and even these are cut and broken still shorter, before they are made into cloth. A few words may be desirable on the growth and shearing of the wool on the sheep.

Sheep are fed for one of two purposes, either for the *flesh* or for the *fleece*. As the modes of treatment and rearing are different in the two cases, any particular

country or district devotes its attention to that one object which, from its circumstances or position, is likely to prove most profitable. Those sheep which are reared principally for their fleece become covered annually with a thick coating of wool: this wool is cut off once a year, and sold to the wool-dealer, from whom it passes to the woollen manufacturer, to be made into cloth, and other articles.

The Merino breed of sheep, originally from Spain, is found to produce wool possessing more valuable qualities than any other: we will, therefore, shortly describe the mode of rearing the animals in the sheep districts of Spain. The fine-woolled sheep live almost wholly in the open air. During the summer months they are driven, in flocks of as many as ten thousand, to the mountainous regions of Castile and Arragon, which are covered with plants healthful to the sheep. The sheep are driven to these pastures in the beginning of summer, and are at first allowed to lick as much *salt* as they please, and a more moderate quantity afterwards. After having remained in the mountains all the summer, they are driven to the southern plains of La Mancha, Andalusia, and especially Estremadura. The journey begins at the end of September, and frequently lasts as much as forty days, the distance travelled sometimes amounting to seven hundred miles. The shepherd conducts them to the pasture which they occupied the previous winter, and where most of the lambs were born. Here folds are constructed for the sheep, and huts made of branches for the shepherds. Shortly after their arrival in the winter pasture, the birth of the lambs takes place. The lambs born latest are put into the richest pastures, to acquire strength for their journey to the mountains in spring. This journey takes place in April, and the same routine of summer pasturage takes place as before. The shearing generally takes place in May, and is done under cover. Before shearing, the sheep are put into a building consisting of two apartments, from 400 to 800 paces long and 100 wide. As many of the sheep as are to be sheared the next day, are taken in the evening into a narrow, long, low hut, called the *sweating-house*, when the sheep, being much crowded, perspire freely: the wool thus becomes softer, and more easily cut. The wool is sorted and washed before being sent away. A ram yields about eight pounds of wool, and a ewe only about five, but the latter is of a finer quality.

The sheep reared for their fleeces in other countries are tended in various ways according to the pasturage which they can obtain; for the pasturage greatly influences the

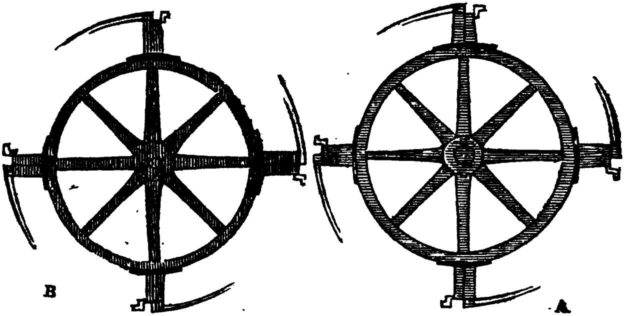
quality of the wool. The process of *shearing* is, in England, a rural holiday, or rather, from the importance with which the operation is regarded, it *finishes* with a holiday. We need not say much respecting the act of shearing a sheep. The animal is caught generally by an hinder leg, and thrown on its back, and the wool is cut off by means of large shears, the shearer being careful not to wound the animal.

The qualities of wool are extremely variable; and it is the office of the dealer to separate the various qualities, so as to suit various markets. We will therefore suppose that the long and the short wool have been separated and sold to the various manufacturers; and will now proceed to speak of the mode of working up the long wool, known as the

Worsted Manufacture.

The long wool is first washed in soap and water, to remove a portion of the grease naturally adherent to it; and is afterwards spread out on a heated floor to dry. The wool is then removed to a machine called the *plucker*, by which the fibres are cleansed and straightened. Still farther to separate and straighten the fibres, the wool passes into the hands of the *wool-comber*, who proceeds as follows:—The workman has two combs with pointed steel teeth, one of which he fixes in a post, with the teeth upwards, and the other he holds in his hand. The wool is separated into handfuls of about four ounces each, and sprinkled with oil. The teeth of the combs are heated, and the workman, taking a portion of wool in his hand, throws it over the points of the comb and draws it through them; and so on repeatedly, a portion of wool remaining each time in the comb. The comb, with the wool adhering to it, is now removed from the post, and laid on a stove to be farther heated; meanwhile the second comb is mounted on the post, and supplied with wool in a similar manner. The three following figures represent the apparatus here alluded to: A is the comb; B is the post to which it is fixed, the handle of the comb being attached to two projecting wires at the post; C is the stove, with the fire-place at A; the teeth of the comb being inserted between two iron plates C D.

When both combs are heated, the comber holds one of them with his left hand, over his knee, and with the other comb, held in his right, he combs the wool upon the first, by introducing the points of the teeth of one comb into the



B A

twisted. These rovings are then spun into worsted thread or yarn, by a spinning machine, the same in principle as that employed in cotton, but differing somewhat in details. The yarn thus produced has various degrees of twist given to it: that for worsted stockings is not much twisted, but that for the *warp* of bombazines, &c., is more hard and twisted. The condition of the yarn as to softness, depends also on the length of the fibres of wool from which it was made; some being more fitted for the preparation of yarn for hosiery; while others yield the firmer yarns required for waistcoat-pieces, carpets, bombazines, crapes, poplins, and other firm fabrics woven from worsted.

When the yarn has been spun, it passes to the weaver, for whom it is more particularly adapted. Each weaver employs a form of loom fitted for the kind of fabric which he produces;—the carpet-weaver one kind, the shalloon-weaver another, and so on. It is to the loom that we must look as the principal source of the peculiarities which we observe in woven materials. It is true that the yarn for the carpet-weaver, for instance, is thicker and coarser than that used by the cotton-weaver; but it is to the peculiarity of the loom employed by the former that the interlacement of the threads of a carpet is due. Still the utter impossibility of showing the points of distinction between looms of various kinds, without an intricacy and minuteness of detail, wholly unsuited to this little volume, must make us content with saying that long wool, spun into worsted yarn, is the material from which carpets and the other fabrics are woven by looms especially adapted for their respective purposes.

The carding-machine now employed for this purpose is somewhat complicated, but its principal parts are represented in the preceding figure. The wool is placed upon an endless cloth or apron, I, from whence it passes between two feeding rollers, K, K; is then combed by a system of rollers, G F E D C B A, revolving round a central cylinder, H. The surfaces of all these rollers are covered with cards or teeth, by which the wool is drawn out and smoothed, and ultimately falls into a cylindrical box, L.

The effect of carding is to separate the woolly filaments, and render the whole light, equable, and homogeneous: it also frequently breaks and doubles them, a circumstance which, while it would be highly injurious in the preparation of *cotton*, is an advantage to the subsequent processes to which *wool* is subjected. The broken fibres, by the peculiar action of the carding-machine, get crossed over each other in every imaginable direction. It is found that the carding thus effected is not only much more expeditious than that performed by hand, as in the old method, but that the fibres become arranged in a manner better calculated to yield the *nap* in the after processes.

The wool then passes into the hands of the *slubber*. This workman, by means of a machine called by the odd name of a *slubbing billy*, reduces the thickness of the cardings by drawing them out in length, and joins them into a continuous spongy cord, giving them at the same time a slight twist, to maintain their cohesion or uniformity. This spongy cord is called a *slubbing* or a *roving*, and is in fact, a kind of soft, thick, fragile thread. The machine by which this is effected occasioned much sensation a few years ago. The reader may recollect that a committee of the House of Commons was appointed to inquire into alleged abuses in the factory system, and among the charges brought before them was one, that children employed in the woollen manufacture were for the smallest neglect frequently beaten cruelly with *billy rollers*. On inquiry, it was found that each *slubbing billy* is attended by a man and four boys —the *slubber* and the *pieceners*. The boys bring the bands of wool from the carding-machine, and lay them on the slubbing billy, slightly fastening the end of one piece to that of another. The man is engaged turning a wheel, and managing some other machinery, by which the wool is drawn out into rovings; and the duties are so arranged, that the four boys provide exactly as much work as the man can perform. All would, therefore, go on well, if the workman kept steadily to his work; but as he is engaged by *the piece*, and can leave the machine when he likes, an evil

arises, which is thus stated by Dr. Ure:—"If he is disposed to leave his business for the pot-house at arbitrary intervals, as many handicraft tradesmen are too apt to do, for half an hour, an hour, or more, a great accumulation of cardings from the power-driven carding engine will ensue in his absence. The children pile these on the floor in heaps called *stacks*, of which they will sometimes have six or seven, containing from twenty dozen to forty dozen cardings in each stock. On the slubber's return from his voluntary absence, he usually sets to work much more violently than common, to clear his drinking score, and to make up for lost time, as he is paid by the piece, or by the *great*, as it is termed. On such occasions the children are tasked to severe exertion, and are often capriciously punished by this independent workman, for unavoidable faults of his creation; for the children have not only to continue piling up the cardings incessantly thrown off by the carding-engine, but also to piecen their slubbing ends with double rapidity." At such times, or whenever the children did not satisfy him in the course of his work, he was not slow to beat them with a roller forming part of the machine, called the *billy roller*. It was fully shown, that the cruelty, which had often been charged upon the manufacturers, was really due to the intemperate and coarse-minded workmen who had charge of the slubbing billies. Since that period, an improved machine has been invented, which bids fair to dispense with the use of the one just named; but the publicity given to the subject by the Factory Commission has done the most to remedy the evil.

The slubbings or rovings of wool are now transferred to the spinner, who spins them into yarn in a manner similar to that adopted by the cotton spinner. The yarn which is to form *warp*, is twisted hard and firm, while that destined for woof or weft is softer and more elastic.

The warp-yarn is conveyed to the warping-frame, where the different threads which are to form the warp are arranged in a parallel and uniform manner. The weaver next works in the weft between and among the threads of the warp, by means of his shuttle, after the manner of the cotton weaver. There is a remarkable difference between cotton and woollen cloth in this respect:—cottons remaining about the same width when they are quite finished as when they leave the loom of the weaver; but woollen cloth, by the peculiar processes which it undergoes after weaving, shrinks to nearly one-half of its woven width; in order, therefore, to produce superfine broad-cloth six quarters

wide, it is customary to weave it to the enormous width of twelve quarters.

There being always a good deal of oil used in the process of carding the wool, this oil still remains throughout the processes of roving, spinning, and weaving; but as it is necessary now to remove it, the woven cloth undergoes the process of *scouring*. A large quantity of cloth is put into a wooden trough, with water and a little soap, and undergoes a process not very dissimilar in effect to the common operation of a laundress. But instead of human hands and arms, two large wooden mallets are used. These mallets are fixed to movable handles, and are made to inflict heavy and oft-repeated blows upon the mass of cloth, "by an action extremely like kicking with the toes," as it has been observed. The cloth is made to turn and roll over and over, so that every part in its turn comes under the action of the mallets. After it has been well worked in this manner with the soap and water, it is a second time scoured with pure water only.

The cloth is now hung up to dry, by being stretched across a vertical frame, to which it is attached by tenter-hooks, which catch hold of the edges of the cloth. Most persons are aware that the narrow strips of cloth called *list* are cut off from broad cloth after it comes into the tailor's hands. This list forms a strong edging to the cloth, through which the hooks are passed which fasten it to the frame; the warp being of additional strength at those parts, in order that they may bear the strain.

When the cloth is quite dry it is removed from the frame, and then goes through the operation of *burling*. It is examined minutely in every part, to see that no imperfections exist: knots and uneven threads are removed, and if the scouring has occasioned any little rents or holes they are carefully sewn up. The ensuing process conceals all these repaired injuries.

Human hair, and almost every fibrous substance of animal origin, has a tendency to *curl* and twist; this tendency in wool is the source of the remarkable effect produced on the cloth in the next process, which is that of *fulling*, or *milling*. We have said that in carding the wool, it is broken into shorter lengths, and that the fibres cross and intermix with one another in every imaginable direction, by which of course many of the *ends* are to be found at every part of a piece of cloth. Now the process of *fulling* is to work up these fibres in a bristly form on the surface of the cloth by powerful beating, making them start out, as it were, as

well as closely wedging up the pores between the threads of the cloth. This so much thickens the cloth that, as before observed, the width becomes reduced to little more than one half. But directly the fibres become loosened and disturbed by the beating, their ends begin to mat and cling together, forming so dense a hairy or fibrous covering, that the threads of the cloth can ultimately be scarcely seen.

According to Dr. Ure, in order to full or mill a piece of cloth sixty-two yards long, six pounds of soap are dissolved in a little water, and a handful of the solution is spread upon every yard of surface. The piece is then placed in a trough, and worked for three hours, being frequently turned to expose fresh surfaces to the blows of two powerful mallets, which fall flat on the folded surface. The fibres of the wool are thus compacted together, sliding more easily among each other in consequence of the lubrication of the soap, till the whole becomes matted into one mass. After three hours' milling, the cloth is taken out of the trough, soaped as before, and then subjected to the mallets for another three hours. This process is repeated four times in the course of twelve hours, and is succeeded by a rinsing operation, a stream of clean water being admitted into the trough to wash out the soap. The piece of cloth is now found to be reduced in dimensions, from sixty-two yards long by one hundred inches wide, to forty yards long by sixty inches wide. The number of hours which the process of milling continues depend a good deal on the quality of the cloth.

During the process of fulling, the heavy mallets, called *stocks*, strike the cloth with a rapidity of thirty or forty strokes per minute; and it is this incessant beating which finally imparts to the fabric, a texture intermediate between common woven materials and the *felt* of which hats are made. Another effect of the fulling process is, that a cut edge does not require *hemming;* whereas cotton, linen, or silk fabrics are loose enough to allow the warp and weft threads near the edge to become loosened and unravelled.

When the fulling is quite completed, the cloth is stretched out in an open place to dry; and is then ready for the process of *teazling*. The object of this is, to raise up the loose fibres of the woollen yarn into a *nap* upon the surface of the cloth. This is done by a kind of scratching motion, either with the prickly flower-head of the teazle (*Dipsacus fullonum*), or with brushes made of wires.

The teazles were formerly used by two men; but they have lately been fixed to a machine called the *gig-mill*. In

the former method a number of teazles were put into a small frame, having crossed handles eight or ten inches long. Being filled with the thistle-heads or teazles, it formed a tool somewhat resembling the horse *curry-comb* used by grooms. The teazle-frame was seized by two men, who, holding it by the handle, scrubbed the face of the cloth, which was either hung in a vertical position from two horizontal rails fixed to the ceiling of the workshop, or placed over an inclined bench or horse. The first time of scrubbing the cloth, it was wetted with water, and worked three times over in the direction of the warp: a second operation similarly worked up the fibres in the direction of the weft.

In order to expedite this process, the teazles were afterwards fixed to a *gig-mill*. This consists of a cylinder bristled over with teazles, and turning rapidly round while the cloth is drawn over it in various directions. When the elastic points or hooks of the teazles get filled with flocks of wool, they are taken out of the cylinder and cleaned by children with a small comb—or, in large factories, by a revolving brush-cylinder.

The plants which yield the teazles employed in the above process are cultivated in the counties of Wilts, Essex, Gloucester, and Somerset. There are several heads to each plant, and these, when they sprout out about July or August, are cut off and exposed to dry. This is done in the open air if the weather permit; but if otherwise, the small farmers, or cottagers, dry them in barns or other convenient places. They are then packed up in bundles of ten thousand each, and sent to market, where they produce from 4*l.* to 20*l.* per pack, according to the relation between supply and demand; but the usual price varies from 5*l.* to 8*l.* The variations of soil and of weather produce so much uncertainty in the supply of teazles, that its cultivation is one of the most precarious in agriculture.

The number of teazles required in dressing a piece of cloth is very great; when the cloth is of fine quality as many as 1500 or 2000 are often necessary; and these are not merely *used* but *spoiled* by the operation, so that a continual supply is needed. This circumstance has induced ingenious men to endeavour to devise a mode of employing metal wires, formed into a kind of scrubbing brush, for this purpose. Many patents have been taken out for new inventions, having this object in view, and some of them are now in action; but we believe that the teazle is still the principal means employed.

If the reader has borne in mind the successive processes

which have been detailed, he will be prepared to understand that the cloth presents a woolly kind of surface, on account of the disturbance of fibres caused by the teazling. To level down this woolly surface, and to produce that beautifully equal and soft texture which we recognise fine broad cloth, is the office of the *cropper* or *shearer*, who takes off a portion of the woolly surface by means of a peculiar kind of shears. When this is done by hand, the cloth is laid down in folds upon a plank or low bench, and the end is drawn across a table or bench, which is covered with cloth, and stuffed with horse-hair like a cushion. The cloth is stretched out flat upon the surface of the table, and retained in its place by hooks and weights. Two workmen are employed to shear. Each has a pair of shears made in a peculiar manner, with large flat blades, which cut the surface of the cloth by a motion not altogether unlike that of *shaving*. One man begins at one edge, and the other at the middle of the width of the cloth, working crosswise, or in the direction of the weft. When they have gone over the whole width of the cloth by repeated cuts, they draw the piece of cloth forwards across the table, and commence shearing a new portion.

Such was the mode of shearing adopted almost universally until the beginning of the present century, when machines were introduced for performing the same operation with greater certainty and expedition. But in this, as in almost every similar instance, the introduction of machinery was viewed with jealousy by the workmen accustomed to the old routine, and serious riots took place, especially in Wiltshire and Somersetshire. A Committee of the House of Commons was appointed to investigate the matter, and they showed their approval of the introduction of machinery by presenting a report, in which it was stated, "That decisive evidence had been adduced before them, by merchants and manufacturers of the greatest credit and respectability, to prove that these machines, when carefully employed, finish the cloth in the most perfect manner; and these manufacturers residing in parts of the country where the gig-mill is not used, frequently sent their cloths to a distance to be dressed by it; that similar alarms had been created among workmen at the introduction of other machines, now admitted to be most beneficial to the trade and to every body engaged in it; for, besides the occupation created by attendance on such machines, a greatly increased demand for labour had resulted from the extended sale of goods, in consequence of their greater cheapness and superior quality."

Since the period above referred to numerous machines have been brought into use, for effecting the operation of shearing cloth; and hand-shearing is almost out of use. There is in every case a broad, sharp, and fine-cutting instrument, the mode of action of which is in general midway between *shaving* and *planing*. The machine now generally employed contains a spiral cutter working against a straight smooth edge; the cloth being drawn between the two.

After the cloth has been sheared, its surface is brushed to remove the loose cuttings. This operation is now commonly performed by a machine furnished with two horizontal drums or cylinders, covered with brushes. The piece of cloth is conducted over a system of rollers, to extend it and draw it slowly forward: it is conducted over one of the brushing cylinders, and under the other; and as they are kept in rapid motion by the machine, they brush over both sides of the cloth at the same time, and lay all the fibres one way.

This brushing is succeeded by the process of *pressing;* it is this which imparts the smooth, even, and glossy appearance to the cloth. The piece of cloth is folded backwards and forwards at every yard, so as to form a solid pack or heap; and between every two folds sheets of glazed paper are placed, so that no part of the surfaces of the cloth can come in contact; also at every twenty yards, three hot iron plates are inserted between the folds, the plates being laid side by side, so that they occupy the whole surface of the folds; and thin iron plates, which are not heated, are also put above and below the hot plates, to moderate the heat. When the pack of cloth is properly folded, it is placed in a screw press or a hydraulic press, and powerfully pressed. The cloth remains in the press until the plates are quite cold; it is then taken out and refolded, so that the creases of the former folds will come opposite to the surfaces of the paper, in order to be pressed with other hot plates.

The nature of this process is this:—The heat tends to soften the fibres of the wool; and the pressure against the glazed paper, whilst they are so softened, lays all the fibres flat and smooth, so that the cloth has a very glossy appearance, and a smooth, satin-like texture. But this high-finish to the cloth is not free from objection; for a shower of rain will remove it, or produce a spotted and disfigured appearance. For this reason, in pressing superfine cloth, the plates are very slightly warmed, and thus the cloth receives but little gloss.

For coarse cloth, the gloss is sometimes communicated by means of a hot iron. For this purpose the cloth is spread out upon a large flat table, and extended by hooks. An iron box, containing a red-hot heater, is suspended by ropes from the ceiling, so that it can be hoisted over to the middle of the table, and then two men work it backwards and forwards over the whole surface of the cloth, by means of two long poles or handles.

When the cloth is quite finished, it is packed up in bales of twenty or twenty-five pieces. Each bale is first inclosed in paper and then in canvas, and lastly compactly pressed.

Bleaching.

It is not often that *white* woollen cloths are required; but when they, or any other articles manufactured from wool, are to be bleached, the process is generally performed on the unspun wool, and it is effected in the following manner.

There is always a considerable amount of oil and greasy matter naturally belonging to the wool; and the principal object is to remove this. Five parts of soft water are mixed with one of an ammoniacal compound, and boiled for a short time. When this has cooled to about 56°, the wool is thrown in, in the proportion of twenty pounds to four or five pailfuls of liquor. After steeping for a short time, the wool is continually stirred about in the mixture for about fifteen or twenty minutes. It is then taken out and drained in a basket; and afterwards completely rinsed by exposing it in baskets to a continued stream of clear water, a workman constantly stirring it with a pole, till the water passes off perfectly clear. The wool is then removed, and a fresh quantity put into the basket, which is to be treated in the same manner. The steeping and rinsing are repeated till the wool has attained as great a degree of whiteness as it is capable of receiving from this operation.

This is the usual operation for coarse wool; but for those varieties which are destined for fine cloths, a different one is pursued. The wool is divided into parcels containing about six and a-half pounds, and each parcel is washed in a lather of two pounds and a-half of green soap in a sufficient quantity of boiling water. There is a kind of clayey earth called *fuller's earth*, which has the property of combining with and removing grease, &c., much in the same manner as soap; and it is largely employed by the wool-scourers, or fullers, instead of soap.

The wool, when thus treated, is smooth, soft, elastic,

open, and whitish; but as the whiteness is not sufficiently pure for many purposes, a farther process, called *sulphuring*, is adopted, after the cloth has been woven. The cloth is hung up on poles in a close apartment, and a quantity of sulphur, placed in very flat and broad dishes, is ignited, and allowed to burn away gradually in the chamber, every aperture by which the vapour could escape being carefully closed. The sulphurous acid vapour generated by the combination of the sulphur with the oxygen of the air of the chamber penetrates the cloth, destroys the colouring matter, and thus completes the bleaching. Everything is allowed to remain untouched for a period varying from six to twenty-four hours, when the cloth is removed from the chamber. We are not aware whether chlorine has been yet employed for bleaching woollen goods.

Dyeing.

The purpose and effect of *scouring* the woven cloth, as recently described, is to remove the oil which has been previously applied to the wool to facilitate the spinning and weaving, since the cloth would not take the *dye* until the oil were removed. The soap, fuller's earth, &c., together with the rubbing and beating action just described, have the desired effect of removing the oil and preparing the cloth for the dyer. We may here observe, that the process of dyeing is performed at different stages of the woollen manufacture, according to the purposes to which the wool is to be applied. If it is to be made into cloth of mixed colours, the dye is imparted to the fleece: if it is to be used for tapestry and other similar purposes, the dye is given to the spun yarn or thread; but in the common manufacture of blue or black cloth, both modes are adopted —"wool-dyeing" before the yarn is spun, or "piece-dyeing" after the cloth is woven, but before it is fulled. Each of these methods has some advantage peculiar to itself.

The woollen cloth made and used in England is so much more frequently dyed blue or black than any other colour, that a short account of the modes of effecting this will serve to convey a general idea of woollen dyeing.

The principal materials for dyeing cloth blue are *indigo* and *woad*, both of which are derived from plants, the former growing in India and the latter in England and other countries. The dyeing is conducted in a large vat. About four hundred pounds' weight of woad is broken up and put into the vat. Thirty pounds of *weld* (a plant yielding a

yellow infusion) are boiled in a copper for three hours in a sufficient quantity of water to fill the vat. To this decoction are added twenty pounds of *madder* (also a vegetable product), and a quantity of bran. The boiling is then continued for half an hour longer; after the liquid has partially cooled, the weld is taken out, and the whole remaining contents of the boiler poured into the vat. The mixture is then raked for a considerable time, in order to incorporate it well together. After a certain time, a portion of quick-lime, and the requisite quantity of indigo, are added, the latter being regulated by the intensity of the blue shade required; from ten to thirty pounds are employed to the proportions above mentioned. After standing several days, and undergoing several rakings, it is again heated, and is ready for the reception of the cloth.

Two hours before the dyeing, the vat is raked; and to prevent the cloth from coming in contact with the sediment, which would produce inequalities in the colour, a net-work false bottom is introduced. The cloth is then completely wetted with pure water a little heated, and being wrung out, is dipped into the vat, where it is moved about for a longer or a shorter time, according to the depth of shade required. During this operation, it is taken out occasionally to be exposed to the air, the action of which is necessary to change the greenish colour of the bath into blue. Cloth dyed blue in this manner must be carefully washed to carry off the particles of colouring-matter; and when the shade of blue is deep, it ought even to be cleansed by fulling with soap; since this operation does not alter the colour.

To produce the tint of blue called *Saxon-blue*, the cloth is first prepared with alum and tartar; and the indigo is dissolved in sulphuric acid, previous to its introduction into the vat.

To dye cloth a good black it is usually first dyed deep blue. It is then boiled for two hours in a vat containing nut-galls and water, the proportion being five pounds of galls to every hundred pounds of cloth. It is, in the next place, steeped for two hours in a solution of logwood and sulphate of iron, in the proportions of thirty pounds of the former to five of the latter. The cloth is not boiled in this solution, but merely steeped. After the dyeing, the cloth is well rinsed in a river or running stream, until the water comes off clear and colourless. A cheaper black is produced by first dyeing the cloth brown, by means of an infusion of green walnut-peels; and afterwards black by the usual means.

Such is a brief outline of the modes of dyeing blue or black; and the difference between these modes and those used for other colours is not so much in the nature of the processes as in the colouring substances employed. For instance, to dye cloth scarlet, the colouring-matter of the *cochineal* insect is employed; for crimson, cochineal mixed with alum, the alkalies, or some of the earthy salts; for yellow dyes, weld, fustic, catechu, anatto, quercitron, and many other bodies; for brown, walnut-peel, sumach, birch bark, sandal wood, &c. It will also readily be understood, that by mixing any two or three of the other substances together, almost every imaginable variety of tint or shade may be produced. Black and blue are, however, by far the predominating colours in English woollen cloth.

These, then, are the most important of the details connected with the cloth manufacture. We may remark, that attempts have more than once been made to produce woollen cloth *without any spinning or weaving whatever;* by making the fibres of wool adhere together by a process in some respects analogous to *fulling*, called *felting;* a process which will be better understood when we come to speak of felting wool for *hats*. Hitherto these attempts have not succeeded; but we think it by no means improbable that such a process will ultimately be adopted.

The value of woollen goods manufactured in England is supposed to amount to about twenty millions sterling annually, of which about six millions are exported. Besides the wool derived from our own sheep, about forty million pounds of foreign wool is imported, and the manufacture is supposed to support about three hundred thousand persons.

Flax is the bark or fibrous covering of the stem of a plant whose botanical name is *Linum*,—a word considered by some to be derived from the Greek verb *to hold*, the fibres of this plant being so remarkable for their tenacity: hence it has always been greatly esteemed for the manufacture of cloth, &c. The flax plant is an annual, requiring to be sown with the seeds of the last year's produce, from the middle of March to the middle of April. It succeeds best in a free open loamy soil; it is certain to produce a good crop on new ground; and will generally thrive on any soil which is proper for barley or oats. It remains on the ground till the end of July or the beginning of August, when it ripens, and is fit to be gathered. It is not cut, but is pulled up by the root.

Russia is celebrated for its hemp. The mode of sorting and drying hemp in that country is as follows:—A circular hut is built near the plantation, and a plot of ground is cleared in front of it, where the sorting can be carried on; while at the side is a rack with several horizontal bars or shelves. The hemp, after being gathered, is laid on the rack to dry,—afterwards spread out upon the ground to be sorted,—and finally stored up in the hut. This is all that we need say respecting hemp; we therefore proceed in our notice of flax.

As the fibrous portion, which is situated between the interior wood and exterior bark of each stalk, is that which is to be afterwards used, means must be afterwards taken to separate it from the other parts. This is effected either steeping the plant in water, or by exposing it on the grass to the action of the dew. The one is called *water-rotting* or *retting*, and the other *dew-retting*. The process of rotting away the woody from the fibrous portions has been employed from time immemorial in many countries; but it is found to be very detrimental to the health, not only of the inhabitants, but also the cattle, in the districts where it is carried on. It becomes the source of many pestilential diseases, among which, perhaps, the *malaria*, so prevalent in the vicinity of Rome and Naples, may be numbered; besides which, since flax and hemp ripen about the month of August, and require to be submitted to this process as soon as they are taken from the ground, the farmer's attention to them becomes necessary at a time when it can least be spared.

According to Mr. Millington, the *water-retting* of the flax is most commonly performed in artificial ponds or canals excavated by the sides of rivers, and generally about forty feet long, six feet wide, and four deep; a sufficient

nicety and hazard to the cultivator. In Belgium the flax is steeped in a running stream instead of a stagnant pool; and the whole process is more carefully attended to than in any other country.

When the steeping in the water is supposed to have been carried to a sufficient extent, the bundles of flax, which have by this time become very tender and difficult to handle, are taken out on boards or trays, and removed to the nearest short grass or heath, where they are regularly disposed in rows to lose their moisture, and in which situation they receive an additional preparation from the evening dews and occasional showers completing the decomposition, and at the same time washing away the slime and mucilage with which they are mixed. This last exposure is called *grassing*, and continues, according to the state of the atmosphere, for four or five weeks, or until the flax is as dry as it can be got, of a clean, good colour, and all the woody matter which remains is perfectly brittle. The fibre will still retain most of its original tenacity, if the operation has been carefully and skilfully conducted.

It is sometimes the plan to spread out the flax in thin layers on the grass as soon as it is pulled, without previously steeping it in water. The disengagement of the fibre from the surrounding materials is effected by the air and dew, but in a longer time than when the flax is previously steeped. This process is termed *dew-retting*.

Braking and Heckling.

When the flax has remained on the grass till the fibres can be easily broken away from the woody portion, it is taken up, a dry day being chosen for the purpose; and being bound in sheaves, is carried to the place where it is to be *broken* or *scutched*. Before this operation of *breaking* or *braking* is performed, it is necessary that the flax should be exposed to the heat of the sun, by placing it against a wall or paling, in a sloping direction, or to the gentle heat of a fire, by putting it over hurdles, or by introducing it into an oven heated by the refuse flax. The heat should be very moderate, and regulated in an equal manner. And in every case the flax should only be suffered to remain just long enough to dispel any dampness that it may have acquired.

The process of *braking* the flax now ensues: this consists in breaking and separating the core from the fibrous flax, and is performed by means of instruments more or less

simple. A common *flax-brake* is composed of three wooden bars fastened longitudinally on a horizontal bench, and of a lever, to the under side of which are fixed similar, but rather smaller bars, which fit in between the interstices of the former. The flax being held in the left hand across the under bars of the brake, the upper bars are then with the right hand quickly and repeatedly forced down upon the flax, which is shifted and turned about with the left hand, in order that it may be fully and completely broken in its whole length. An improvement was afterwards made, by which the machine was put in action by the foot, and thus the effect was produced in a more complete manner. Subsequently, instruments of a more complicated kind have been invented; but these we need not particularly describe, as the effect which they are designed to produce is merely to break away the fibrous flax from the other portions which are not required, and to separate it.

The flax is now ready for the process of *hackling* or *heckling*, which bears some resemblance to wool-combing. The heckle is a strong comb composed of a number of rows of iron or steel pins, several inches long, fixed upright in a square block of wood as a base, across the pointed summits of which the lock of flax is thrown, and drawn through the teeth either by hand or mechanical power. As considerable force as well as art are requisite to heckle well without injuring the flax, the block must be made fast to a bench, in front of the workman, when the operation is a manual one. Coarser and wider-toothed heckles are used first, and then others progressively closer-toothed, as the fibres become finer by separation. The effect of this heckling is to divide, clean, and straighten the fibres of flax.

Into this, as into most other similar manufactures, machinery has been introduced. The heckling points are now generally attached to the circumference of a cylinder, and the flax being made to pass through them, it thus becomes heckled. In ordinary flax-mills the fibres are first roughly heckled by hand, in the way just described, and then carried to a machine, where they are heckled in a more complete manner. Boys, called *machine-minders*, and occasionally girls, tend these machines, fixing the portions of flax in the proper places, removing them from coarser to finer heckles, and finally removing them to make room for others. In this part of the work there is frequently a species of injustice somewhat similar to that practised by the *slubber* in the woollen manufacture, to which we before alluded. Dr. Ure thus speaks of it:—"The locks of flax are screwed into the holder by a boy called the *screwer*,

generally younger than his companion the *machine-minder*; and his labour appeared, to a most intelligent factory commissioner, to be, beyond comparison, the most fatiguing that he had seen children subjected to, independently of the noxious atmosphere, loaded as it is with particles of flax incessantly detached and scattered by the whirling of the machines. The *screwer* seems not to have, with the common-heckling machine, an instant's cessation from labour; bunch after bunch is thrown down before him, to fix and unfix,—actions performed by him with incredible rapidity. If he does not do his work properly, he mars the work of the *machine-minder*,—generally a bigger boy, and is apt to suffer the usual punishment inflicted by the stronger work-people on the weaker, who happen to obstruct their labour and their gain,—annoyance or oppression in some shape or other. If the difference of age or strength were the same between the *machine-minder* and the *screwer*, as between the *slubber* and *piecener* in wool-spinning, there is little doubt that the ill-treatment, which is in our factories now almost exclusively the reproach of the slubber, would find its parallel in a flax-mill." Recent improvements in the heckling-machines, and the supervision of the factory inspectors, have done much to remove some of the evils here alluded to.

Sorting and Roving.

The operation of *heckling* divides the flax into *line* and *tow;* the former being the long, clean, straightened fibres; and the latter the short, dirty, fibrous matter combed off from among the flaxen locks. The heckled flax, or *line*, passes into the hands of the *line-sorters*, whose business it is to sort it, according to its fibre, into different degrees of fineness. It is now at the same stage as long wool when delivered by the combers or combing-machine. Girls or women, called *line-spreaders*, are then employed to unite the locks of *line* into one sliver or band, exactly like the *breakers* in the worsted factory.

The flax is now in a condition to go through the operation of *roving*, that is, being drawn out, or elongated into a slender and tolerably regular pipe or tube, preparatory to the operation of spinning. By referring to page 30 the reader will see the object and the nature of the process of roving *cotton;* and the effect of the similar operation upon flax so nearly resembles it, that a separate description is not necessary. We may merely observe, that machines

for effecting this process have been gradually improved upon by repeated patented inventions.

A tolerable idea of the connexion between the various parts of the flax preparation, *after* the braking, and *before* the spinning, may be formed from a description which Mr. Barlow has given of the operations in an extensive flax manufactory in Yorkshire. The building consists of five floors, and the operators, of which there are more than twelve hundred, are principally girls from ten to twenty years of age. The propelling powers are two seventy-horse steam-engines, one on each side of the building. Each of these drives a series of vertical shafts acting on one shaft which passes through all the floors; and on each floor there are bevelled wheels on this main shaft, which drive various others, lying in a horizontal direction, some of them extending in length to one hundred and thirty feet. From these, and cylinders, upon them supplied with proper straps, all the machinery on each floor is driven, every strap having pulleys for putting the machinery in or out of motion.

The flax is delivered at the mill, from the grower, after it has gone through the process of *braking*. In this state it is conveyed from the wagons, by a lifting apparatus like that of a flour-mill, to the upper floor of the building, where it is opened, and where the process of spinning, or rather the preparation for spinning, is commenced.

The flax, in the state in which it is received, is from twenty-six to thirty-six inches in length, and the first step is to divide a quantity of it into three lengths: the part nearest to the root being coarse and strong, the middle part fine and strong, and the upper part still finer but not so strong. Thus each length being divided into three, and all the parts from the bottom, middle, and top, being collected into separate heaps, three distinct qualities of thread are to be formed.

The separation of these first lengths into three is effected by a very ingenious machine, consisting of a number of vertical wheels, and a centre wheel furnished with teeth. The length of flax is held transversely against these wheels, and is passed between two, one on each side, while the centre wheel tears it across by separating but not cutting the fibres. This cuts off the bottom part of the length of flax: the remaining part is then submitted to the same process, and the middle part is cut from the top, each sort being collected in one heap, so as to effect a separation of the three qualities. Each division varies in length from about nine to twelve inches.

In the next stage these lengths are fixed in a sort of vice at one end, and spread out to a breadth of six or eight inches. Several of these are fixed on a sort of revolving cylinder, at distances of about a foot from each other, their unsupported ends falling on a series of combs or heckling points. As the combs revolve in one direction and the flax in an opposite, the lengths of flax become combed out very smooth and straight; they are then dextrously removed by an attendant, generally a girl, and placed with the other sides downwards, and exposed to the action of a similar set of combs. Then again they are removed to a cylinder containing finer heckle-teeth, and so on until, for the finest qualities, the flax has passed through ten or a dozen heckling-machines.

These several operations being performed, the next step is to place these pieces of flax, end to end, on what is called a *feeding-cloth*, and by the hand slightly to combine their ends. The first end is then passed between two rollers furnished with teeth, which carry the whole forward, while the extreme end passes between two iron rollers, the latter moving with considerably greater velocity than the former, in some cases in the proportion of thirty to one; the effect of which is, that the flax is lengthened thirty times, and proportionably reduced in thickness. In passing from the roller, the flax receives no twist, but comes out flat and of about the breadth of narrow tape, and is caught in a cylindrical can placed below to receive it. When a certain length has been received sufficient to fill the can, the machinery rings a bell; an attendant breaks the flax, removes the can, and places another. The flax in the full can is then taken to another machine, where it is again lengthened, and so on, to different degrees according to its intended fineness. After it is properly reduced in the flat state here described, it receives in the last stage a very slight twist, so as to reduce it to a round, thick, soft kind of thread, called a *roving*. It is then ready for spinning.

Spinning and Weaving.

One marked point of difference between the spinning of cotton and that of flax is, that the latter must be *wet* during the process, in order to produce a close and smooth yarn. It is necessary to pass the *rovings* through a trough of water placed at the back of the spindles; in consequence of which a dewy spray is constantly thrown off in the front of the frame from the yarn, as it is rapidly twirled in the process of spinning. And as another spinning frame is placed at no great distance, the spinner is exposed to this small rain both in front and in rear; whereby he may, without certain precaution, have his clothes thoroughly soaked through in a few hours, especially if stationed between two frames placed very near together. Dr. Ure observes, "This may be considered the inherent evil in flax-spinning: the spray thrown off by the wet yarn, as it whirls about with the flyer of the spindles. A working dress, indeed, is generally worn by the spinners; but unless it be made of stuff impermeable to water, like Macintosh's cloth, it will soon become uncomfortable, and cause injury to health, by keeping the body continually in a bath. In some mills, water-proof cloth and leather aprons have actually been introduced; which are the only practicable remedy, for the free space which must be left round the spindles for the spinner to see them play, is incompatible with any kind of guard or *parapluie*."

Within a short period it has become customary in some factories to wet the flax with *hot* water instead of cold, as it is found that a much finer, smoother, and more uniform thread can be spun thereby: the flax formerly spun to twelve pounds the bundle, is by this method spun to six. But the spray of hot water is still more uncomfortable to the workman than that of cold. A contrivance has therefore been partially adopted, by which the troughs can be covered up, by which the increased heat and dampness of the room is somewhat obviated. But the spray from the whirling rovings of flax still continues, and no method has yet been devised by which this annoyance can be removed.

These remarks on flax-spinning are all which will be necessary to say on the subject; for the actual process of spinning is almost precisely similar to that of cotton; the same remark also applies to *weaving*. When the flax for linen has been spun into yarn, and the cotton for calico has

also been spun into yarn, the modes of weaving those yarns respectively into linen and calico are almost identical, and do not call for a repetition of our description.

Supposing then that a piece of linen has been woven from flax yarn, we will next make a few remarks on

Bleaching.

Little need be said on this point, for reasons just stated. It has been found that the colouring-matter of flax is not chemically combined with the fibrous threads constituting the bark of the stalk; but that a chemical combination takes place while the plant is steeped in water. This being the case, it seems doubly desirable that some mode of separating the fibres from the wood should be adopted, which would not require that the flax should be so long steeped in water. An attempt has been made to effect this, and at the same time to save the necessity of bleaching the linen hereafter to be woven; but we believe that such attempts have not hitherto been successful.

The process of bleaching linen is nearly the same as that employed for cotton; but it is more difficult to effect the former than the latter; hence the boiling with an alkaline ley, and the steeping in the solution of chloride of lime, must be repeated three or four times. In general, the linen is exposed upon the grass to the sun for some weeks, though this part of the process is not essential. The loss of weight which linen sustains during bleaching amounts to about one-third part of the whole weight of goods, whereas cotton scarcely sustains a loss of one-tenth part.

It was formerly very much the practice to bleach flax in the state of yarn, by the slow process called *grass-bleaching*, before chlorine was discovered. The first operation, called *steeping*, consisted in immersing the brown yarn in hot water, or in allowing it to macerate in cold water, or in alkaline ley. The next operation was that of *bucking* or boiling in an alkaline ley; after which the yarn was exposed on the grass, for two or three weeks, which latter operation was called *crofting*. These alternate operations of bucking, washing, and crofting, were generally repeated four or five times, each time lessening the strength of the alkaline solution in which the bucking was performed. The next process was that of *scouring*, which consisted in soaking the yarn in sour milk, which was usually employed, for the first time, immediately after the fourth or fifth bucking. In this liquor, which was technically called the

first sour, the goods lay for three weeks, or until such time as the scum began to crack and subside, when they were usually taken out and submitted to a repetition of the processes already described. These tedious operations were afterwards much shortened by substituting sulphuric acid for the sour milk; but chlorine has now effected a revolution in almost every department of the bleaching trade.

Dyeing.

Woven fabrics made of flax are, generally speaking, much less frequently dyed than those formed of cotton, wool, or silk. But when such a process does take place, it is conducted in precisely the same manner as in the dyeing of cottons.

In concluding this notice of Linen we may state that the quantity of flax for linen, and hemp for sails, cording, &c., imported every year into England, is estimated at 1,500,000 cwt. Of the linen manufactured (and which is supposed to be worth about seven millions sterling annually), about two millions are exported. The number of persons engaged in the linen manufacture is supposed to be about two hundred thousand.

Chapter V.

SILK.

If *Cotton* be the most generally useful of woven fabrics, *Silk* is unquestionably the most beautiful. The fineness of the thread or yarn which the weaver employs, the splendid colours which it is capable of receiving, and the delicate gloss which distinguishes woven silk goods, have been universally admired. But there are yet other qualities to recommend it. Silk is a very strong material, considering the thinness of the fibres; it resists fire better than cotton fabrics will do; and it is beautifully soft to the touch.

There is, perhaps, nothing more wonderful in the whole range of the useful arts, than the production and manufacture of silk. That a worm two or three inches long should spin from its body a minute glutinous filament;—that it should form a ball, or "cocoon," with that filament;—that man should take the cocoon, unwind the filament from it, spin it, and convert it into cloth: all this forms a subject so attractive, that we must venture to enter into it somewhat more fully than we have done into the three preceding subjects. In treating of cotton, or wool, or flax, the details which precede the labours performed in our factories are not very extensive, because neither the plants which yield two of these, nor the animal which yields the other, are difficult to rear. This, however, is not the case with silk; the details which precede the importation of the raw material into England are more important than those which succeed it. The rearing of the silk-worm will therefore be well deserving of our attention.

Cultivation of the Mulberry-tree.

As the produce of the silk-worm depends almost entirely on the food consumed by the animal, and as the *mulberry leaf* is the kind best adapted to its habits, it will be proper to say a few words respecting the cultivation of the trees, before describing the rearing of the worms.

The mulberry-tree is called *Morus* by botanists, and comprises seven species, of which five are employed for the nourishment of silk-worms. The white variety, or *Morus*

alba, however, is the one which the animal prefers, and which is most extensively cultivated for this purpose. Moist lands in valleys and near rivers are favourable to a rapid growth of the trees, but not to the development of nutritious qualities in the leaf; while dry soils give few leaves to the trees, but these are of an excellent quality.

The mulberry-tree is raised by cuttings, layers, or seed. The following directions apply to the mode of cultivation in France:—Take the ripe mulberries when they are full of juice and seed. Next take a rough horse-hair line or rope, and, with a good handful of ripe mulberries, rub the hand along the line, bruising and mashing the berries as much as possible, so that the pulp and seed of the berries may adhere in great abundance to the rope or hair line. Next, dig a trench in the ground, such as is frequently used for crops of various kinds in kitchen gardens; and after having cut the rope or hair line into lengths, place it full of the mashed berries into the trench: the trench is then filled up with earth, and afterwards frequently watered. The seeds will grow and soon shoot out suckers, which will bear young leaves fit for the silk-worm to feed on. In this mode of rearing, the trees or shrubs do not attain a greater height than a raspberry, currant, or gooseberry bush.

One writer states:—"The most easy and expeditious way of raising mulberry-trees is from cuttings. Although as great a number cannot so readily be raised in this manner as from seed, there is a greater advantage in point of strength as well as in the rapidity of their growth. This method of propagation is much more successful in moist and temperate climes than in such as are exposed to the arid heat of the lower latitudes. Cuttings will put forth shoots of about five or six inches in length during the first summer, and will, at the same time, be providing themselves with roots. If they have put forth shoots, and preserve their leaves until the autumn, the plants will generally succeed: any which have failed to do so, must be replaced by other cuttings. In the course of the ensuing spring and summer, if carefully watered, the shoots will frequently attain the length of eighteen inches. In the autumn following, the beds must be thinned, and the redundant saplings planted out."

The Chinese allow their mulberry-trees to attain a moderate height; but they so prune them that the leaves may be gathered in the easiest manner. They are, with this view, cut in a hollow form, without any intersecting

branches in the middle; so that a person going round the tree may gather all the outside leaves, and afterwards, by standing withinside, and merely turning round to the different parts, may pluck the leaves growing within. The trees are not allowed to grow to any great height; so that each tree forms a sort of round edge, and thus the leaves may be reached without climbing on the branches.

The leaves may be gathered as soon as they appear; but it is injurious to the tree to pluck them before the fifth year. As there is a good deal of sap in the trees, they will produce two crops of leaves in one season, and thus furnish food for two broods of silk-worms. A well-cultivated mulberry-tree will yield about thirty pounds' weight of good leaves, or if large, much more than this; and the rearers of silk-worms in the south of France purchase the leaves at market,—an office requiring some sagacity; for it is found that of the saccharine, the resinous, the fibrous, the watery, and the colouring constituents of the leaf, the saccharine only is the part which sustains the insect, and causes it to increase in size; and as the leaves vary in the proportion of these constituents, it is necessary to be able to judge those which are best fitted for the purpose. The young leaves are fittest for young worms, and the old leaves for old worms.

It has been stated by more than one naturalist, that no insect whatever, except the silk-worm, feeds on the mulberry-leaf; a statement which, if true, is not a little curious.

The reader will now understand that mulberry-trees are carefully cultivated, in order that their leaves may be used as food for silk-worms; and he may now naturally inquire, "Is there no other vegetable production fitted for this purpose?" A similar question has often been asked, and many investigations have been entered into on the subject. The Reverend Mr. Swayne fed some silk-worms on white mulberry-leaves, others on those of the black mulberry (the fruit of which is common in England), and others on *lettuce*-leaves, for the purpose of comparing the effects produced. The worms who had been fed on lettuce were of a pale colour, and grew rapidly; but the result seemed to show, that, although lettuce-leaves may yield nourishment to the insect, they contribute little towards the secretion of that peculiar matter from which the silk is produced. Subsequent investigations by an ingenious lady, Miss Rhodes, showed that lettuce-leaves, under certain precautions, were more advantageous than had hitherto been supposed. But for some reason or other, the rearing of

silk-worms has never prospered in England to much extent; and we do not believe that lettuce-leaves are employed by foreign countries.

Another lady employed the leaves of the blackberry, the elm, the primrose, the cowslip, and some other plants, at a season of the year too early for the mulberry-leaves; and the worms ate of them with avidity. But a singular proof was afforded of the natural instinct of the insect; for when the young mulberry-leaves appeared, and the worms had once tasted of them, they would not again touch their previous food.

A French lady has recently found that the leaves of the *scornozera* (viper-grass) will answer tolerably well as a substitute for mulberry-leaves. But every attempt hitherto made to supersede the use of the mulberry-leaf has failed of complete success. Why this should be the case,—why this particular plant should be the favourite food of these remarkable insects,—is a question which cannot be answered until we possess a larger amount of knowledge both of animal and of vegetable physiology.

Rearing of Silk-Worms.

The silk-worm undergoes four different changes. In the first instance, an *egg* is hatched by the warmth of the spring, and a *caterpillar* emerges; this, as it enlarges, progressively casts its skin three or four times, according to the variety of the insect. This caterpillar attains maturity in about twenty-five or thirty-days, when it ceases to eat for the remainder of its (caterpillar) life, seeming to be no otherwise employed than in discharging a peculiar substance, from its body, and spinning a *cocoon* or egg-shaped nest round itself as a defence from enemies and external impression. Within this dwelling the caterpellar changes to a *chrysalis* or *nymph*, in which it remains in a torpid state for fifteen or twenty days. Suddenly it bursts through its cocoon or nest, and comes forth to the light of day an *insect* provided with wings, antennæ, and feet. In this butterfly state the insect exists for about two months.

Such is the natural career of the silk-worm; and as the *cocoon* is the production which man afterwards appropriates to his own use, attention is directed to the best means of obtaining from each worm the greatest amount, and the best quality of cocoon.

We must trace the life of this singular little being step

by step in order to understand the subsequent formation of the silk. The rearer of silk-worms places white cloths or sheets of paper for the reception of the eggs produced by the female butterfly. These eggs, which average about three hundred in number from each insect, adhere to the cloth or paper by means of a kind of gum with which they are covered. They are of a yellowish colour, and about as large as grains of mustard-seed.

The living beings within these eggs are hatched by means of heat, as in other oviparous animals. But here an important circumstance claims the attention of the rearer: the mulberry-tree shoots forth its leaves only at certain seasons of the year, according to the climate; and if the eggs were hatched at a period when the mulberry-leaves were not to be procured, the worms would not thrive for want of their proper food. Means are therefore taken to prevent the eggs from hatching until the proper season arrives. Sometimes the eggs are imported into one country from another; and in order to prevent them from hatching in the interim, they are carefully dried, and placed in glass phials, which are then closely sealed to exclude air and moisture. The phials are immersed in earthen pots filled with cold water, which is renewed as often as it becomes warm. The Chinese, in order to preserve the eggs, suspend the sheets of paper containing them to a beam of the rearing-room, the windows of which are opened to admit air. In a few days the papers are taken down and rolled up loosely with the eggs withinside, in which form they are hung again during the remainder of the summer, and through the autumn. Towards the end of the year they are immersed in cold water containing a small quantity of salt. In this state the eggs are left during two days; and on being taken from the saline solution, are first hung up to dry, and are then rolled up rather more tightly than before, each sheet of paper being afterwards inclosed in a separate earthen vessel.

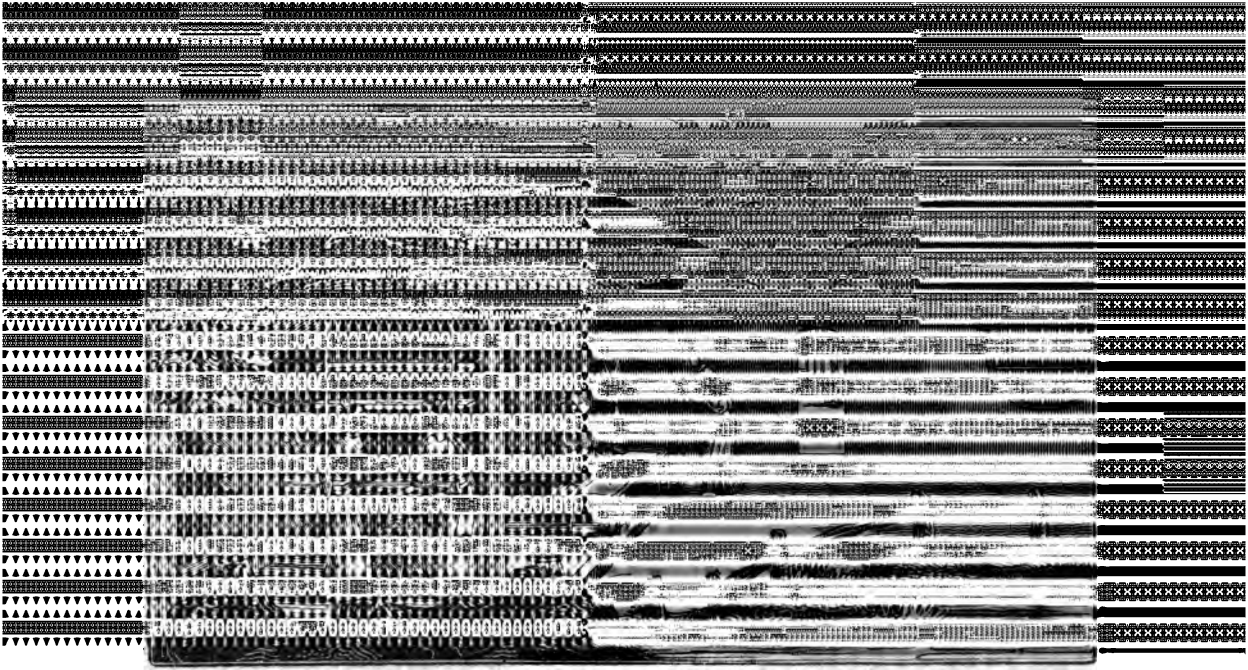
Supposing the eggs to have been properly preserved until the mulberry-tree has produced its leaves, preparations are made for the hatching. Numerous plans have been adopted for this purpose. In some districts the peasants fold the eggs up in small paper packets, and keep them in their bosoms until the warmth prepares the eggs for their approaching change: in other places the warmth of the sun is employed; but the plan now more generally adopted is to place the eggs in rooms artificially heated. According to the method recommended by Count Dandolo, an Italian nobleman who bestowed considerable attention

on the rearing of silk-worms, the following is the routine:— The cloths on which the eggs have been deposited by the worm, and to which they adhere, are agitated for five or six minutes in a vessel containing water, in order to lessen the adhesion between them and the cloth. Having then suffered the water to drain from them during two or three minutes, the cloths are stretched out on tables, and the eggs gently scraped from them, by an instrument whose edge is not sufficiently sharp to injure the shells, nor so blunt as to crush them. The eggs are placed in water and washed, to remove a farther portion of the gum; and the water being drained from them, they are washed and gently rubbed in sound light wine. They are then laid on some absorbing substance to strain and dry, in an atmosphere of about fifty degrees.

The eggs are, when quite dried, placed in a room heated by stoves to about the temperature of 64°. Two days afterwards the temperature is raised to 66°; and on each following day the heat is increased one or two degrees, so that on the tenth day it has attained the height of 82°, which point is not exceeded. The eggs now assume a whitish colour, which is a sign that they are about to be hatched; and by the application of a microscope, the worm may be seen within the shell. Sheets of white paper are now pierced with holes and placed on the eggs: the worms break their shells, crawl up through the holes, and station themselves on the upper surface of the paper.

This minute worm or caterpillar immediately shows an appetite for food, and will travel a short distance in search of it, if a supply is not made for it by the rearers; but the habits of the insect are so little of a migratory nature, that, if furnished with proper food, it will not wander above three feet from the spot of its birth during the whole of its brief career. The rearer, therefore, for the purpose of collecting the insects in the rearing-house, where they can be properly fed, and their silk taken care of, places small twigs of mulberry on the paper. The newly hatched worms immediately crawl upon these leaves, and begin to eat with avidity; meanwhile the sheets of paper, with the worms and the mulberry-twigs, are placed in boxes, or well-lined baskets, and carefully secluded from cold air until removed to the rearing-house. This house must be dry and warm, and free from insects, smoke, and unpleasant odours, which are likely to injure the health of the delicate little worms.

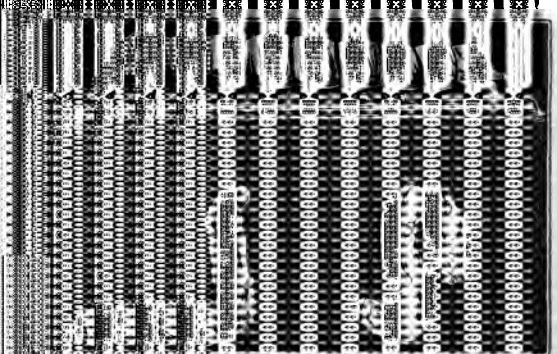
The worms are placed upon shelves in the room, and fed with mulberry-leaves cut up into very minute portions.



Feeding the Silk-worms.

The cut on the opposite page is copied from a Chinese drawing, and represents females feeding the worms. They are fed several times a day, the quantity given to them being such that the worms from one ounce of eggs eat about six pounds of leaves in the first eight days of their existence. By the end of these eight days, their good living has so nourished them that they have attained the length of a quarter of an inch, and their weight has so much increased, that although 54,000 of them were required to make an ounce when they quitted their eggs, 3,800 will now weigh that quantity. A change of a remarkable kind now ensues: the insect is literally too big for its skin; it has grown so fast that the skin will no longer stretch or grow proportionably; it appears to become ill, and refuses all food. This continues three days, during which the animal is making exertions to burst through, and shake off the skin, which now almost stifles it. A kind of humour is sent out by the insect, which lubricates the surface of the body beneath the skin; and at last, by rubbing the head and body on the surface of a leaf, it succeeds in breaking the skin in a few places, and then vigorously disengages every part of its body from its old covering — not only the body, but the feet, the jaws, and even the teeth, are found to shed the skin which before covered them.

The animal seems now to feel as if it had a new lease of existence, and commences feeding again with much vigour, which continues for five days; during this period the worms originally produced from an ounce of eggs consume about eighteen pounds of leaves, and grow to the length of half an inch; while their weight is so much increased that only six hundred of them will now go to an ounce. A second period of sickness now occurs: the insect's outer covering seems too confined, it ceases to eat, and in three days undergoes a second moulting, in exactly the same way as before. It again resumes its feasting on the mulberry-leaves, and their increased size enables the same number of worms to eat sixty pounds of leaves, in the next five days. This increases their length to nearly an inch, and their weight to such a degree that 144 will weigh an ounce. A third sickness of three days follows this, after which a skin is again shed, and the insect again seeks eagerly for food, which his increased bulk enables him to eat in such quantity, that one hundred and eighty pounds are devoured by the same number of worms as before spoken of, in five days. This leads to a fourth illness, and, after an abstinence from food for three days, to a fourth rejection of skin, when the insect presents itself of the comparatively large size of an



are some few who, although they may not have all the requisites for rearing worms in perfection, yet have care sufficient to preserve them from very severe disease.

"I have found, on entering the rooms in which these insects were reared, that they were damp, ill-lighted by lamps fed with rancid oil; the air corrupt and stagnant to a degree that impeded respiration; disagreeable effluvia disguised with aromatics; the wickers too close together, covered with fermenting litter, upon which the silk-worms were pining. The air was never renewed except by the breaches which time had worn in the doors and windows; and what made this more sad and deplorable, was the knowledge that the persons who attended to those insects, however healthy they might have been when they entered upon the employment, lost their health, their voices became hollow, their hues pallid, and they had the appearance of valetudinarians, as if issuing from the very tomb, or recovering from some dreadful illness."

In addition to the general weak and sickly state of the worms consequent on absence of fresh air, and the natural light of day, two active diseases may be noticed: the one is called the *jaundice*, in consequence of the yellow colour it produces on its victims; and the other *muscardine*, because the body of the dead worm resembles certain sugar-plums manufactured in Provence, and called *muscardines*. This disease is produced by the formation of a minute cryptogamous plant in the interior of the body of the living animal. This vegetable substance grows so rapidly, that in a few days it kills the worm, bursts through its skin, covers the whole body with vegetation, ripens its seeds, which, falling upon other worms, soon produce a fearful mortality. The two lower figures in the foregoing cut represent the animal struck with muscardine.

The cut in the next page gives a highly magnified representation of this vegetable parasite. The roots at and about *a* grow from the fatty substance of the worm, and spread in all directions; these roots send out numberless branches, such as *b*, some of which are furnished with little buds, as at *c*, while others have lobes, as at *d*.

So fatal and extensive in its effects is this disease, that on two or three occasions the Royal Academy of Sciences of Paris have officially directed naturalists appointed by that learned body to inquire into the circumstances of this malady, and to suggest, if possible, a remedy. The last inquiries have been very successful, not only in determining the origin and nature of the disease, but also in suggesting remedies. It would exceed the limits of our present

confined space in which to work. Such a place being found, and the insect having ceased to eat, its future labours are thus described:—"In twenty-four hours from the time of its abstaining from food, the material for forming its silk will be digested in its reservoirs; its green colour will disappear; and its body will have acquired a degree of glossiness, and will have become somewhat transparent towards the neck. Before the worm is quite prepared to spin, its body will have acquired greater firmness, and be somewhat lessened in size. The substance of which the silk is composed is secreted in the form of a fine yellow transparent gum, in two separate vessels of slender dimensions, which are wound as it were, on two spindles in the stomach: if unfolded, these vessels would be about ten inches long. The worm begins its labour by spinning thin and irregular threads, which are intended to support its future dwelling. During the first day, the insect forms upon these a loose structure of an oval shape, which is called *floss-silk*, and within which covering, in the three following days, it forms the firm and consistent yellow ball called the *cocoon;* the labourer, of course, always remaining on the inside of the sphere which it is forming. The silky material, which, when drawn out, appears to be one thread, is composed of two fibres, extracted through two orifices near the jaws; and these fibres are brought together by means of two hooks, placed within the silk-worm's mouth for that purpose. The worm in spinning rests on its lower extremity throughout the operation, and employs its mouth and front legs in the task of directing and fastening the thread. The filament is not spun in regular concentric circles round the interior surface of the ball, but in spots, going backwards and forwards with a sort of wavy motion. This apparently irregular manner of proceeding is plainly perceptible when the silk is wound off the ball, which does not make more than one or two entire revolutions while ten or twelve yards of silk are being transferred to the reel."*

While the worms are forming their cocoons, it is of great importance to attend to the temperature of the room. If the air be cold, they will desist from work: while the cocoon is sufficiently thin, the insect may, under such circumstances, be discerned either quite inactive, or moving very slowly. If the temperature be again raised, they will resume their labours with renewed activity, and will again

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* *Cabinet Cyclopædia*, "Silk Manufacture."

desist if the temperature be again lowered. But if the coldness of the air be too long continued, the insect will change from its caterpillar form without finishing the cocoon.

The change here spoken of is a remarkable one. After the worm has been busily engaged in weaving its cocoon during three or four days, it ceases its labours, and the cocoon presents itself as a yellow ball, about the shape and nearly of the size of a pigeon's egg. The next operation of the insect is to coat the internal surface of the cocoon with a kind of gum similar to that of which the silk is made: this seems to be intended by the insect as a varnish to protect it from the rain, for the filaments of the cocoon are not water-proof in their natural state, although they are covered with a glutinous coating which makes it partially so. The "water-proofing," however, which the insect applies to the interior of the cocoon is so complete that, although the cocoons are, when about to be reeled, thrown into hot water to facilitate the winding of the silk from them, the water seldom penetrates to the cavity within until the silk is nearly all wound off.

The career of the insect within the cocoon is different when it follows its natural instinct from that which it is forced to undergo by its rearer. The natural progress is this:—The large quantity of silken material which the insect emits from its body necessarily reduces its bulk to a great extent: it becomes wrinkled, and the rings of its body approach nearer to each other and appear more decidedly marked. It now remains quiet and torpid within its dwelling for some days, in the form of a chrysalis, with a smooth brown skin, shaped somewhat like a kidney bean, and rather less than an inch in length. Its existence in this form continues from twelve to thirty days, according to the climate. At the end of this long period of torpor, a total change has come over the insect: it moistens the gum which lines its cocoon by ejecting a peculiar liquor from its mouth; and then, by pushing and working its head against the silken fibres, manages to break an opening between them, and effects its escape into air and light in the form of an elegant little moth or butterfly. This little being flutters about, and enjoys a transient winged existence for two or three days, and then ceases to exist.

Such is the natural course of the insect; but it is found that if the moth is allowed to break through the cocoon, it destroys the continuity of the filament of silk, and thereby depreciates its value. The insect is therefore killed shortly after the cocoon is completed. For this purpose the cocoons

are exposed to the sun for four or five days, or placed in a heated oven, or exposed to the steam of boiling water. In any one of these cases, the insect becomes suffocated.

We have said that the Chinese prepare frames or mats on which the worms may spin their cocoons. The cut on the preceding page represents some persons sifting and cleaning the cocoons on the mats, to clear them from leaves, dust, &c., previous to removing them from the frames.

We may here present, in a tabular form, a few facts concerning the natural growth of the insect. We have stated that there are five periods in the history of the worm, from the time it is hatched, till it begins to spin the cocoon. These periods are separated by four seasons of sickness, during which the insect does not eat; but during the intervening periods, which last from five to seven days each, according to the climate, it eats vigorously. Count Dandolo watched the progress of the worms from five ounces of eggs, and found the quantity of food consumed by them as follows:—

1st Period.

	lb.	oz.
1st day —	1	7
2nd.........	2	7
3rd.........	3	0
4th.........	6	0
5th.........	5	0
6th.........	2	14
	20	0*

2nd Period.

	lb.	oz.
1st day —	5	14
2nd.........	11	0
3rd.........	15	14
4th.........	15	0
5th.........	7	0
6th.........	1	0
	55	0

3rd Period.

	lb.	oz.
1st day —	14	0
2nd.........	30	0
3rd.........	40	0
4th.........	60	0
5th.........	50	0
6th.........	20	0
7th.........	2	0
	216	0

4th Period.

	lb.	oz.
1st day —	50	0
2nd.........	85	0
3rd.........	120	0
4th.........	130	0
5th.........	160	0
6th.........	70	0
7th.........	5	0
	620	0

5th Period.

	lb.	oz.
1st day —	120	0
2nd.........	180	0
3rd.........	240	0
4th.........	310	0
5th.........	360	0
6th.........	450	0
7th.........	550	0
8th.........	650	0
9th.........	500	0
10th.........	290	0
11th.........	190	0
	3820	0
1st Period —	20	0
2nd.........	55	0
3rd.........	216	0
4th.........	620	0
	4731	0

We here see the extraordinary fact that five ounces of little living beings just emerged from their eggs, consumed

* In Italy, pounds and ounces vary greatly, not only in different states, but in the same state; in the present case there are 28 ounces to the pound.

nearly 5000 pounds' weight of leaves in thirty-seven days, the produce of which was four hundred pounds of cocoons of silk.

The variation in weight may be estimated from the following table:—

	GRAINS.
100 silk-worms weigh, in the egg, about	1
100 silk-worms weigh, after the first change, about	15
100 silk-worms weigh, after the second change, about	94
100 silk-worms weigh, after the third change, about	400
100 silk-worms weigh, after the fourth change, about	1600
100 silk-worms weigh, after the fifth change, about	9500
100 silk-worms weigh, in the chrysalis form, about	3900
100 silk-worms weigh, in the moth form, about	1200
100 dead moths weigh about	350

In the silk districts of France it is calculated that for every million pounds' weight of raw silk produced, two hundred and fifty million pounds of leaves are consumed, and that five million trees, of the average age of thirty years, are stripped to furnish them.

Gathering and Sorting Cocoons.

We must now take leave of these wonderful little insects, and watch the progressive steps by which man converts the cocoons into articles of clothing.

After the worms have been spinning for seven or eight days, the cocoons are gathered; they are gently removed from the spot to which the insect had attached them, and handed over to a person who sorts them. The sorting is an object of much care. A few of the cocoons are preserved for continuing the race of the insects: those chosen for this purpose are sound, compact, and of a fine thread; they are about one-sixtieth of the whole number of cocoons procured, and are preserved by stringing them together on a thread, care being taken not to pass the needle too deep into the silk. These strings are then hung up in festoons, and so remain until the chrysalis has become a moth and breaks through the cocoon.

Those cocoons which are to be used for their silk are sorted according to their quality. The white and the yellow are put into separate baskets, the former receiving most kinds of dye better, but the latter yielding the greatest weight of silk. The soiled, imperfect, or double

cocoons, are separated from the others: a double cocoon is occasioned by two worms having commenced their labours too close to each other, by which their nests become combined, and consequently entangled and injured.

The chrysalides are then stifled in their cocoons. We have said that this is effected in various ways by means of heat. Sometimes the cocoons are placed in long shallow baskets, which are nearly filled, and covered, first with paper and then with a cloth wrapper; when, by an hour's exposure to a moderate heat in the oven, the vitality of the insect is destroyed. In other places a large wooden vessel is provided, into which boiling water is poured to the depth of two feet. Within this vessel is a wicker hurdle, entirely covering the water, and supported a little way above its surface. The bottom of the hurdle is covered with coarse porous cloth, on which the cocoons are placed; the vessel is then closed, and the heat of the steam gradually destroys the insects. There can be no doubt that steam might be employed in a more efficacious manner than this.

When the chrysalides are destroyed, the cocoons are dried and placed on shelves, and carefully watched to see that they do not become mouldy: the shelves are also so placed that rats cannot get to them; for these animals are exceedingly fond of the insects, and will eat through the cocoons to get at them.

The cocoons preserved for their silk have been divided into nine different qualities, which are thus enumerated in the *Cabinet Cyclopædia*:—

1st. *Good cocoons* are those which have been brought to perfection; these are by no means the largest, but are compact and free from spots.

2nd. *Pointed cocoons* have one extremity rising in a point: these, after affording a little silk in reeling, break or tear at the point where the thread is weak, and they cannot be wound farther, as their fracture would occur as often as the thread reached the weak point.

3rd. *Cocalons* are rather larger than regular cocoons, but do not contain more silk, their texture being less compact. These are separated from the other kinds, because in winding they must be immersed in colder water, to avoid any furzing or entangling in the operation.

4th. *Dupions or double cocoons.* The threads of these are so intertwined, that frequent fractures occur in reeling; and sometimes they cannot be wound at all. In any parcel of cocoons the proportion of these will usually amount to one per cent.

yards in length: it is the produce of twelve pounds of cocoons: these cocoons are formed by two thousand eight hundred silk-worms; and these worms have consumed a hundred and fifty-two pounds of mulberry-leaves. Whenever, therefore, any one of our fair countrywomen has sixteen yards of silken attire upon her person, she may reflect on the rather astounding fact, that nearly three thousand little insect-workmen laboured to produce it, and that an amount of food more than equal to the average weight of the human body was consumed in so doing.

While the chrysalides are yet in their cocoons, out of one thousand ounces of cocoons, the insects weigh eighty-five, leaving fifteen as the weight of the silk forming the cocoon.

Reeling.

The cocoons pass into the hands of persons who wind off the silk from them in one continuous thread. This may either be done on the spot, or the cocoons may become an article of commerce, and pass from hand to hand. The process of reeling is, however, much the same in principle everywhere, although it may differ somewhat in detail.

The first thing to be done is to remove the *floss*-silk which forms the outer coating of the cocoon: this is effected by opening the floss at one end, and protruding the hard compact ball from within it.

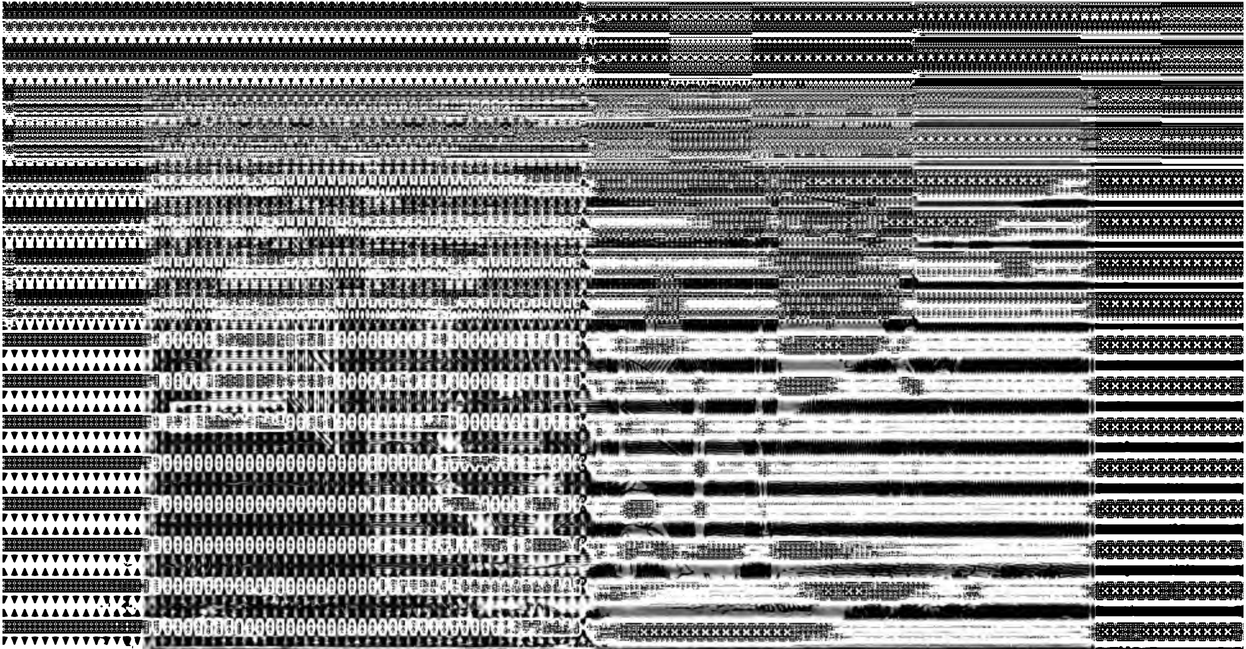
The familiar domestic employment of winding a ball of cotton upon a wooden reel, will convey some idea of the reeling of silk. Each quality of cocoon must be reeled separately, as different modes of proceeding are required for them. In Piedmont, the best cocoons are reeled as follows:—A number of them are put into a trough about half a yard wide, and six inches deep; this trough is filled with water, which is heated by a fire beneath. The heat of the water moistens the gum which agglutinates the fibres of silk, and separates them, but without washing all the gum from the filament. Soft water is preferable for this purpose, as that which is denominated *hard* usually contains some earthy salts, which retard the moistening of the gum on the cocoons.

When the cocoons are sufficiently moistened that the filaments will separate easily, the female who attends the machine, and who is called the *reeler*, sits down at the side, and gently presses the cocoons with a brush made of fine twigs or heath. The loose threads of the cocoons are thus

made to adhere to the brush, and are drawn out by its means. The reeler then, after having disengaged them and drawn their ends through her fingers to clear them from any loose flossy silk, passes four or more of them through an eye or small hole in a metal bar. Two of these compound threads are then twisted twenty or thirty times round each other, in order that the filaments may better unite by these mutual crossings, and likewise that the whole may assume a cylindrical form. This doubly-compound thread is then extended to the *reel,* which is a revolving-frame, round which the silk is to be wound. A boy or girl then turns a handle which sets this reel in rotation, and one end of the thread or filament being attached to it, it gradually, by its motion, winds off the whole of the silk from the cocoons. Fine as the reeled silk is when it comes into the hands of our manufacturers, it is eight or more times as thick as that which the cocoon yields, for the contents of eight or more cocoons are united or twisted into one. In the process of reeling, as often as a thread of any single cocoon breaks, or comes to an end, its place is supplied by another; so that the same number is continually kept up, and a thread of the same substance may be continued to any length. The single filaments which are thus from time to time added, are not joined by tying, but are simply laid on the compound thread, to which they will adhere by means of their gum; and the ends, being extremely fine, do not occasion any perceptible unevenness in the spot whereon they are laid.

If the threads lay one over another in a confused heap on the reel, they would be likely to adhere. To prevent this, they are made, by an ingenious adaptation of machinery, to traverse slowly the whole length of the reel from end to end, so that one layer of threads makes a great number of revolutions in the air before another layer covers it, by which the gum is sufficiently dried to prevent the adhesion of the threads.

This process is continued until a quantity of silk is wound on the reel sufficient to form what is called a *skein.* The reel is then removed from the frame, set aside to dry, and stripped of its silk by slipping it off at one end of the reel. Each skein is then tied round in one or two places, to keep it in shape, folded into a *hank,* and is thus prepared for market. The filament of silk forming the skeins consists of a number, varying from one to one hundred, of the filaments of the cocoon; but the greatest number thus combined by the reeler is generally about thirty, as it



Winding Silk from the Cocoons

requires much care to cause so many to unite and form an even thread.

In the foregoing cut some Chinese females are represented winding silk from the cocoons. The reeler has left her reel for the purpose, apparently, of blowing the fire under a kind of boiler which contains the cocoons.

A considerable degree of attention and of intelligence is required by the reeler. When the threads from two or more cocoons are to be joined, attention must be paid to the various parts of the cocoon, for the thread near the outside is double the thickness of that on the inside: she must therefore unite an additional quantity when their ends are thin. She must also be careful not to drag up and incorporate with the thread any of the husk of the dead insect: she must throw more cocoons in the hot water as fast as the old ones are unwound, and must be careful that the temperature is neither excessive nor defective: if the heat is deficient, the ends will not be well joined, the silk will be harsh, and the adhesion of the fibres of which it is composed will be so slight, that the thread breaks by the application of the smallest force, and the least moisture will separate its filaments; while, if the water is too hot, the threads prove what is techinally called *dead*, and are without firmness.

When all the good silk is wound off the cocoons, the remainder, which forms a portion of the interior, together with the *floss*-silk and other waste, are laid aside, to be afterwards *carded* and spun, a process which is not necessary with good silk.

A woman and a girl, with a reel capable of working two skeins at once, can reel a pound of fine silk in a day. They begin with two skeins, which, when completed, are set in the shade to dry, without being removed from the reel; these two skeins will occupy the morning's labour. In the afternoon, another reel is fixed on the frame, and two more skeins reeled in a similar way, which are afterwards set aside to dry, and are then removed from the reel and tied up in skeins and hanks. A skein usually contains about four hundred yards, and is sold by weight, the unit of weight being a *denier*, which is somewhat less than a grain. The quality of silk is usually denoted by the number of cocoons employed to produce the thickness of a single thread,—such as eight-cocoon, twenty-cocoon, &c.

The writer whom we have before quoted, remarks: "Information obtained from an accurate and very intelligent observer, leads to the conclusion that the establishments for reeling silk in France, are much inferior in their ar-

rangements to those of Italy. The principal cause assigned for this inferiority, is the want of some general regulations, which in some measure would control the mode of conducting the process. It is said that the Piedmontese silk owes the reputation it has so long enjoyed, and which it continues to sustain, to regulations imposed by the government at an early period after the introduction of silk cultivation into that country, and which are still very strictly enforced. The tendency of these regulations is not only to obtain good silk, but to procure also regularity in size, and uniformity in the working of the machines employed for reeling. The proprietor of a silk filature (reeling establishment) in Piedmont, before he commences the business of reeling, is obliged to announce to a local board of commissioners the number of boilers he intends to use, and the thickness and weight of silk which he means to produce in the season. A smaller quantity than five hundred pounds' weight of silk is not allowed to be reeled in a single filature. The various establishments are visited during the season of reeling, by the members of the commission; and should any person be found operating on a greater or lesser number of cocoons than he has previously reported, or otherwise in any way infringing the regulations, a fine is imposed. Nothing of this kind exists in France; and in consequence there is found an infinite variety in the size of the reel and the thickness of the silk. Some wind off their cocoons with cold water, some with hot, and others again use steam for softening the tenacity of the cocoons. Most cultivators of silk in France reel the cocoons they have produced, even though these should not weigh more than twenty pounds. In many places the reelers are paid according to the silk wound, and without reference to its quality; a system which naturally tends to carelessness and improper haste, as well as to the production of only the coarser qualities of the material."

In this instance it seems as if Government interference led to the production of an improved material. But it would be better if such an effect could be brought about by private competition, for a never-failing chain of evils attends this kind of interference of the legislature with manufacturing industry. A good quality of reeled silk is produced in Piedmont; but in such a way that the rich cultivator has a monopoly, and the poor one is embarrassed, because he cannot work up so large a quantity as the Government has declared shall be a minimum in each establishment.

Throwing.

We now arrive at that process in the silk manufacture which is called *throwing*, and which bears the same relation to silk-weaving as spinning bears to cotton-weaving: it is, in short, preparing the warp and weft to be used by the silk-weaver.

The cocoons from which the moths have been suffered to make their escape, and which are called *royal* cocoons, together with the defective cocoons, which cannot be *reeled*, and therefore do not come into the hands of the thrower, are spun by a distaff and spindle. They are first boiled in water from half an hour to an hour. The two sorts which still contain the chrysalis are then beaten, to disengage them from the insect, which is thus reduced to powder. The cocoons so prepared are placed on a distaff, and spun according to the ancient mode of performing that operation. Sometimes the silk is carded before it is spun, by which its appearance is improved, and its price enhanced. The coarse floss-silk and refuse are also carded and spun.

But the larger proportion of silk produced from the cocoons is neither carded nor spun, but is reeled and then transferred to the *throwster*.

The silk is first twisted loosely into what are called *singles;* and the singles are twisted to form *tram* for the weft, or *organzine* for the warp, the latter being far stronger and more carefully prepared than the former. In fact, singles, tram, and organzine, form three different stages of complexity; and one connected description of the mode of preparing organzine from the hanks of raw silk, will include singles and tram as two of its stages. We shall detail the various processes as they were formerly effected by simple machinery, as these can be more easily understood than by the complex machines of modern times.

The first operation is, to wind the raw silk from the skeins, upon what are called *bobbins*, in the winding-machines. To effect this each skein of raw silk is opened and stretched round the circumference of a revolving-frame, which is made of such a size as just to receive the skein. There is, above this revolving-frame, a bobbin, which exactly resembles, only on a larger scale, the reels on which sewing-cotton is wound. Through the intervention of some ingenious machinery, the frame and the bobbin are both set into rotation, and the silk is wound off from one to the other. This continues until the skein is all wound off, or

until the bobbin is full, when a new skein, or a new bobbin, as the case may be, is put in the place of the former one. The bobbins have a motion to and fro, besides a rotatory one, by which the silk is wound in regular layers from one end of the bobbin to the other. Each winding-frame transfers several skeins at once to an equal number of bobbins; and a proper use of the moving power might work several frames at once. The constant attention of children upon the winding-machine is necessary, in order to join the ends of any threads which may be broken in winding, and to replace the skeins and bobbins when necessary.

The silk being thus wound on the bobbins, is sorted into different finenesses and qualities, in order that such kinds may be afterwards twisted or spun together as will produce a silken thread of the desired thickness.

The next operation is that of twisting or spinning each individual thread in a mill, by which it acquires that form called *singles*. This is effected in a manner very nearly the same as that employed in spinning cotton. The long filament of silk is unwound from the bobbins on to a long roller; but in its passage from one to another it is *twisted*. The bobbins are fixed upright in a frame, and the roller is fixed horizontally above them; and this very circumstance alone is sufficient to twist the filament in passing from one to another. If we fix a reel of thread upright on a table, and wind the thread from it upon a horizontal roller or stick, or if the reel were horizontal, and the stick vertical, we should find that the thread receives a slight additional twist by that contrariety of motion. The same kind of operation performed on a delicate filament which is not twisted at all, and aided by certain mechanism to regulate the motion of the bobbins and rollers, enables the silk-throwster to give any amount of twist to his *singles* that may be necessary.

These singles are the elements from which *tram* and *organzine* are now to be made: the singles for the latter are more firmly twisted than for the former; and the combination of singles to form them has this difference in the two cases—that to form *tram*, the singles are twisted together in the same direction as each individual single has been twisted, as in *twine;* while organzine resembles *rope,* where the combined strands are twisted in an opposite direction to that given to the separate threads. This difference is effected by reversing the direction of the motion of the wheels &c. in the spinning or throwing-machine.

The next operation, then, is to bring together upon fresh bobbins two or more threads already twisted in the form

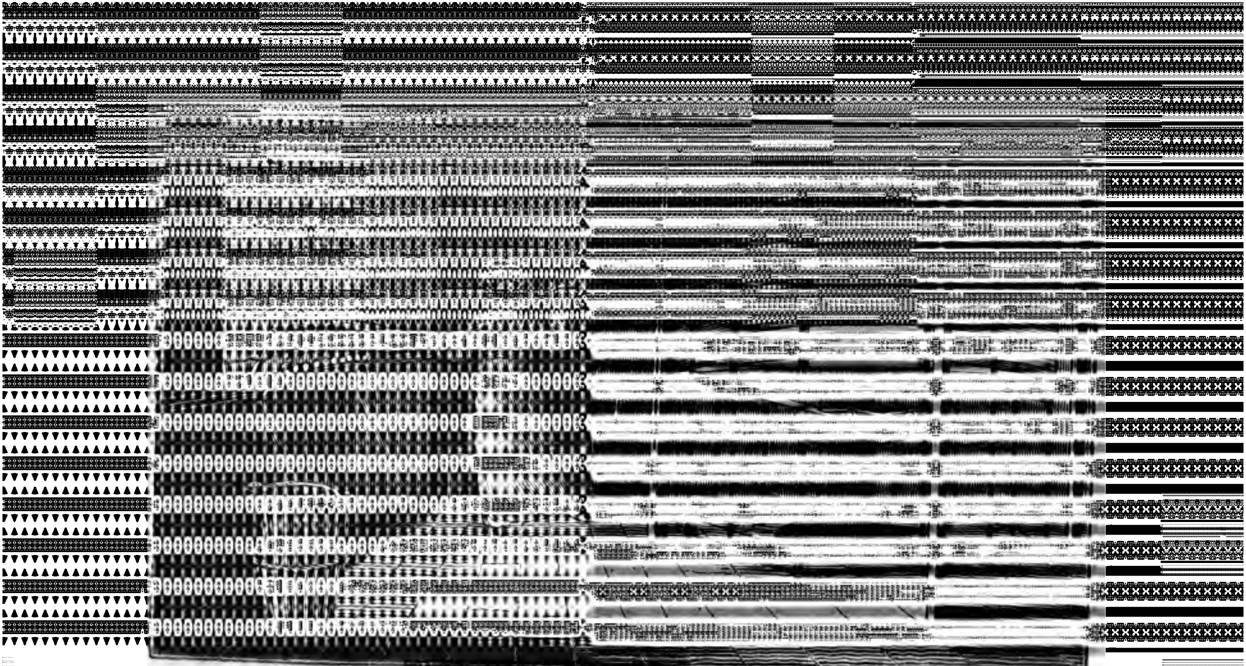
of singles. For this purpose two or more bobbins are placed side by side in front of a machine, and the threads from all of them are made to pass through a wire eye, and from thence to a larger bobbin, receiving a slight degree of twist in their progress, just sufficient to make them keep together. The operation is very similar to that before described, by which the skein of raw silk is wound upon a bobbin; but in the present case two or more threads are combined into one.

To twist or spin these combined threads into a firm, thicker thread, is the object of the next operation, which is performed in the same manner as the former spinning, but in a direction which is changed according as the silk is to form tram or organzine. The silk is now transferred to a large revolving-frame, from which it can be easily slipped off in the form of a *skein*.

The silk has now assumed that form in which it is fit for the weaver. But it contains a substance which must be removed—namely, the gum with which the insect covers it; and although it has assisted to combine the filaments, that assistance is now no longer wanted, since the silk has been twisted by a machine, and the gum renders the silk harsh to the touch, and unfit to receive a dye. The silk is therefore boiled for about four hours in a plentiful proportion of water, into which a quantity of soap, equal to about one-third of the weight of the silk, has been placed; this assists in dissolving the gum, and in rendering the silk soft and glossy. It is then well washed in clear water, to get rid of the soap; and on being dried, it is found to have acquired a peculiar glossiness and softness, and to have increased in bulk, but decreased in weight.

Such is an outline of the processes by which the filaments of silk are brought into a condition fit for the weaver's purpose. It is said that, notwithstanding the extent and the excellence of English machinery, the Italians are able to make better organzine silk than the English. The reason of this has been supposed to be, that the former keep, for the purpose of organzining, the best raw silk from their cocoons, and sell the inferior quality to other throwsters; and also that the journey to England injures the raw silk which our throwsters import. Within a few years, however, the quality of English organzine has greatly improved.

It is not necessary to describe the various pieces of machinery which have been invented to perform these processes more completely; for their object is, generally speaking, merely to cause the work to be done quicker.



Warping-Mill Used by the Spitalfields' Silk Weavers.

We will, however, say a few words respecting Sir Thomas Lombe's machine. In a former chapter it was stated that he borrowed (or as some would say *stole*) his idea from the Italian throwsters, and that government afterwards gave him a sum of money for his services. The Piedmontese were so exasperated at the injury done to their trade, by the introduction of silk-throwing into England, that they sent over an artful woman, who is said to have caused the death of Lombe, by managing, in the disguise of a friend, to administer poison to him. But be this as it may, the establishment which he founded at Derby was certainly an extensive one. The building contained five stories—or we may say *contains*, for it is still in operation: in the three upper ones were the Italian winding-engines, which were placed in a regular manner across the apartments, and furnished with many thousand reels and spindles, and engines for working them. In the two lower rooms were the spinning and twist-mills, all having a circular form. The spinning-mills were eight in number, and gave motion to upwards of twenty-five thousand bobbins. The whole of this elaborate machine, though distributed through so many apartments, was put in motion by a single water-wheel, twenty-three feet in diameter, situated on the west side of the building. All the operations, from winding the raw silk, to organzining or preparing it for the weavers, were performed here. The old water-wheel has been removed within a few years, and other changes have been made.

Weaving.

If the reader has attended to the process of cotton-weaving, as described in a previous chapter, he will have no difficulty in understanding how a piece of silk goods is woven; the processes are, in fact, almost exactly alike: the warp is stretched out in the loom, and the weft is worked in among it, by nearly the same operations in both. But the fineness of silk renders additional care necessary in many cases:—a piece of silk twenty inches in width will frequently have eight thousand threads to form the warp: and to arrange these with regularity requires no small care.

Still, however, as the mode of transferring the silk from the bobbins to the loom differs somewhat from that adopted with cotton, we will shortly explain it. The bobbins (fig. 1) on which the silk is wound are taken by the warper,

and arranged as in fig. (2). The threads from the bottom row of bobbins pass over the lower bar, and those from the upper over the upper bar. These threads are then tied together, passed between the two pulleys on the left of the engraving, to the *warping-mill*, on which the silk has to be wound, and there placed on the pin, as at D (fig. 3). The warper now passes her fingers between the threads of the warp, taking, alternately, a thread from the upper and lower row of bobbings, as seen in fig. (4), and slides her hand along until she reaches the pin over which the ends of the warp, which are tied together, are placed. Lifting it then off the first pin, she replaces it in the manner seen in fig. (5); another pin, E, preserving the threads in their place. Before the warp is removed from the mill, the threads are secured in their alternating situation by tying them together where they cross each other, as at F.

The silk is then wound on a large frame, as seen at page 110, which represents a Spitalfields' warper at work. The frame is made to revolve, by which the silk becomes wound round it in one continuous spiral. The silk is then removed from the frame, and conveyed to the loom. There it is wound equally round the warp-beam, and two long sticks, A A (fig. 6), are introduced between its alternate threads, to supply the place of the two pins on the warping-mill. It is then stretched out and connected with the *heddles*, and the process of weaving commences, nearly the same as in the cotton manufacture.

Ribbons are generally woven by a loom called the *Dutch Engine loom*, in which several sets of warps are arranged side by side, so that many widths of ribbon can be woven at once. An intelligent workman can weave about a yard of each length of ribbon in an hour; and this is the principal employment of the weavers at Coventry, whose looms amount to 10,000. Some ribbons are seen to have a little vandyke or scalloped fringed edging on each edge. These are produced in a singular manner. The outer threads of the warp are made of horse-hair instead of silk; and when the ribbon is woven, these horse-hairs are drawn out, and leave a sort of fringed series of loops, which form what is called a *pearl edge*.

Figure-weaving is as elaborate in the silk manufacture as is that of cotton. All weaving in which a *pattern* is to be wrought, or in which threads of different colours are introduced, may be called figure-weaving. In this operation there must be as many shuttles as there are differently-coloured weft-threads; and the difficulty then is, so to elevate some threads of the warp, and to depress others, by

means of the heddles to which they are attached, as to introduce the weft or cross-thread in the proper positions for forming the figure or pattern. A great number of heddles is required for this purpose, and a weaver on the old system would be much embarrassed to know which heddles to depress at the proper moment; for the smallest mistake in this respect would at once spoil the pattern.

This difficulty was fully felt by the early weavers, and attention was paid to the construction of the loom, for the purpose of devising improved methods of proceeding. This led to the construction of the *draw-loom*, by which the weaver could produce any desired pattern, with nearly the same amount of personal care and trouble as in plain-weaving. The chief improvement effected in this loom was to enable the weaver to draw down the heddles and loom-threads with increased precision, so as to be sure of introducing the weft at the proper place. This machine received many improvements in the course of time; but it was destined to be supplanted by one still more complete and useful.

M. Jacquard, a straw-hat manufacturer in France, had an opportunity, after the peace of Amiens, to get a sight of some English newspapers. In these he read an advertisement or paragraph, purporting that the Society of Arts would give a reward to any person who could weave a net by machinery. He had not previously turned his mind to the subject of machinery; but being roused by this announcement, he set his faculties to work, and produced a machine capable of weaving a net. The disturbed state of France prevented him from drawing any profitable results from his labours, so he soon discontinued his machine, and made a present of it to a friend. This machine ultimately became known to some persons in authority; and Jacquard was one day sent for by the prefect of the department, who said to him, "You have directed your attention to the making of net by machinery?"—Jacquard had almost ceased to think about his machine, but he answered in the affirmative. On being desired to make another machine similar to the former, he requested three weeks' time for so doing. At the expiration of the period, he produced his machine, and requested the prefect to press his foot on a particular part of it: he did so, whereby a mesh was immediately added to the net,—thus exemplifying the powers of the machine.

The machine thus made was sent to Paris, where it soon came to the knowledge of Bonaparte, who ordered Jacquard to be sent for immediately, and to be strictly guarded,—a

proceeding which would somewhat astonish an English inventor. On being brought into the presence of Bonaparte and Carnot, the former is said to have addressed him thus:—"Are you the man who pretends to do what God Almighty cannot do, to tie a knot in a stretched string?" Jacquard was then shown a loom which had cost 20,000 francs, and which had been employed for making fabrics for Bonaparte's own use; and he undertook to make a loom which should do the same work better and quicker. He did so, and the result was the famous *Jacquard-loom*, which has now superseded almost every other for figured-silks. He returned to his native town, and was rewarded with a pension of 1000 crowns. But he experienced a similar lot to that which most inventors are subjected to, viz., the opposition of persons who worked by means of the old looms. Even some of the chief directors of the silk-trade at Lyons broke up his loom in the public place, sold the iron and wood for old materials, and denounced him as an object of universal hatred and ignominy; in short, he was three times exposed to imminent danger of assassination.

But clamour of this kind usually dies away when the advantages of the new method come to be perceived. Not only is the Jacquard-loom used universally in France, but, in the course of a very few years after its first introduction into England, it entirely superseded every other method of figured-silk weaving, and has greatly contributed to the beauty of such productions at the present day.

The mechanical parts of which the Jacquard-loom consists are very numerous, and even a lengthy description, illustrated with cuts, would be insufficient to give a perfect idea of its action; and as it has not been part of our plan to give minute descriptions of machinery, it is not necessary to apologize for passing over the Jacquard-loom with the general details here given.

We have not yet spoken of *power-weaving*, that is, weaving in which the heddles are drawn down, and the shuttle thrown by means of machinery. Such machines have, however, been employed in weaving silk, as well as other fabrics, although not to so great an extent as for cotton. The first introduction of power weaving was due to the Rev. Mr. Cartwright, a clergyman, who was not only unconnected with manufactures, but had never even seen the operation of weaving in his life. A letter which he wrote to the Chamber of Commerce of Glasgow, gives so modest and interesting an account of the invention, that we will quote it.

"Happening to be at Matlock in the summer of 1784, I fell in company with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning machinery. One of the company observed, that as soon as Arkwright's patent expired, so many mills would be erected, and so much cotton spun, that hands never could be found to weave it. To this observation I replied, that Arkwright must then set his wits to work to invent a *weaving-mill.* This brought on a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and, in defence of their opinion, they adduced arguments which I was certainly incompetent to answer, or even to comprehend, being totally ignorant of the subject, having never at that time seen a person weave. I controverted, however, the impracticability of the thing, by remarking that there had lately been exhibited in London an automaton figure which played at chess. 'Now you will not assert, gentlemen,' said I, 'that it is more difficult to construct a machine that shall weave, than one which shall make all the variety of moves which are required in that complicated game.'

"Some little time afterwards, a particular circumstance recalling this conversation to my mind, it struck me that, as in plain-weaving, according to the conception I then had of the business, there could be only three movements which were to follow each other in succession, there would be little difficulty in producing and repeating them. Full of these ideas, I immediately employed a carpenter and a smith to carry them into effect. As soon as the machine was finished, I got a weaver to put in the warp, which was of such materials as sail-cloth is usually made of: to my great delight, a piece of cloth, such as it was, was the produce. As I had never before turned my thoughts to anything mechanical, either in theory or practice, nor had ever seen a loom at work, or knew anything of its construction, you will readily suppose that my first loom must have been a most rude piece of machinery. The warp was placed perpendicularly; the reed fell with a force of at least half a hundred-weight; and the springs which threw the shuttle were strong enough to have thrown a congreve-rocket; in short, it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. Conceiving, in my great simplicity, that I had accomplished all that was required, I then secured what I thought a most valuable property by a patent, 4th of April, 1785. This being done, I then condescended to see how other people wove; and you will guess my astonish-

ment when I compared their easy modes of operation with mine. Availing myself, however, of what I then saw, I made a loom, in its general principles nearly as they are now made; but it was not till the year 1787 that I completed my invention, when I took out my last weaving patent, August 1st in that year."

This was the original of all the power-looms for plain-weaving that have been since employed. At first it was supposed, that the delicate nature of silk would not admit of its being woven by a self-acting machine; but subsequent improvements have rendered the power-loom as applicable to silk as to other plain fabrics.

The cut on the next page represents a Chinese female weaver at work. That remarkable and stationary people still adopt the same modes of weaving as they did centuries, and perhaps thousands of years, ago.

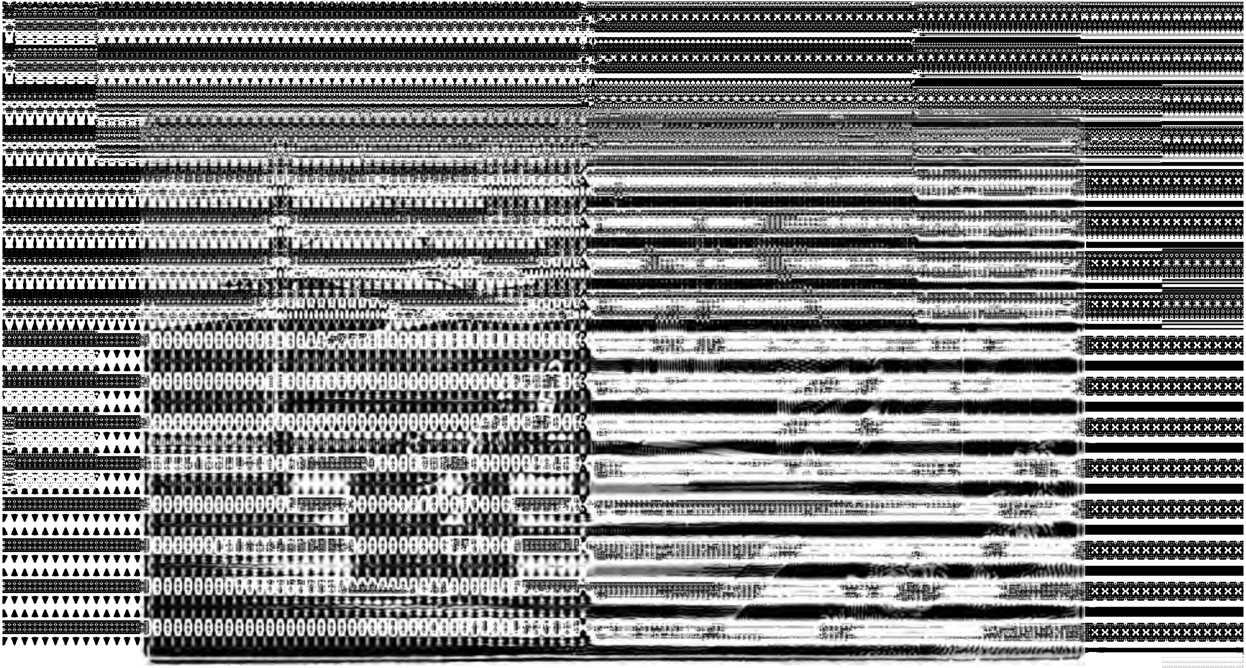
Varieties of Woven Silks.

We will now take a rapid view of the principal points of distinction among various woven fabrics of silk.

Velvet is one of the most beautiful productions of the silk-loom. It has been known in Europe for several centuries; but the secrets of its manufacture were for a long time confined to some of the chief cities of Italy, from which country the French learned the art, and succeeded in improving it. The revocation of the Edict of Nantes brought numerous French refugees to England, about the year 1685, who settled in Spitalfields, and practised the art of weaving velvet.

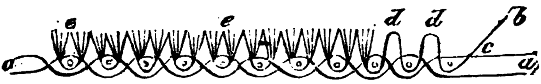
In the weaving of velvet, in addition to the warp and woof, as already described in plain-weaving, there is a soft shag, or pile, produced by inserting short pieces of silk-thread, doubled, under the woof, and these stand up in so large a number, and so compactly, as to conceal the interlacings of the warp and woof which are seen in plain-weaving. This silky pile imparts to velvet its peculiar softness to the touch, as well as beauty to the eye; but the production of these results depends in great measure upon the uniform evenness of the pile. To insure this latter quality, it is necessary to have all the threads of the pile of equal length, which requires some skill, and much patient attention on the part of the weaver.

In weaving velvet, the loom is first prepared as in the ordinary process of plain-weaving: another set of threads



Chinese Female Weaver at work.

is then prepared to go in the direction of the threads of the warp, which set is kept distinct from the warp by being stretched diagonally as shown in the figure, which represents the structure of velvet, and the plan adopted to



Section, exhibiting the structure of Velvet.

combine the threads of the woof with the pile. At *a a*, are the threads of the warp, and the dots placed in the loops show the section of the woof-threads: at *b* are the threads intended for the pile, and these threads meet those of the warp in the angle *c*. The weaver places in this angle a brass wire of the same length as the breadth of the piece of woven stuff, so that all the pile-threads are above the wire, and those of the warp below it. By the action of the treadles the alternate threads of the warp are raised, the shuttle is thrown, and passes over the pile-threads, and the alternate threads of the warp, which are depressed; the batten is then made to strike up against the woof, the interlacing of the warp and woof is effected, and a loop of the pile-thread is formed over the wire as at *d d*. It is necessary to pass the shuttle thrice between each insertion of the wire: the thread for the first woof is coarser than that employed for the other two, and the action of the batten forces the wire into its proper position. The upper part of this wire has a groove running along it: by means, therefore, of a sharp-edged tool, called a *trevat*, passed along the groove, the loops *d d* are divided, the wire is liberated, the pile is formed as at *e e*, and thus the process of weaving velvet is completed.

The weaver, however, finds it necessary to employ two wires, one of which remains in the texture, while the other is cut out: the reason for this is, that the pile-threads may not be liberated and the whole process deranged; but as one wire is secured by the threads of the woof, the pile-threads are prevented from being set at liberty while the loops are being cut. As soon as the wire is liberated from the first loop *d*, it is again inserted in the angle *c;* and when it has been secured as before, the wire forming the second loop *d* in the figure, but now the first loop, is cut out, and so on alternately. At one time the richest velvets

were formed of thirty-eight loops to the inch, but this beautiful substance, velvet, has been so much in demand, and persons are willing to pay such high prices for the richest productions, that now as many as fifty-five loops are woven into an inch of velvet. This circumstance will enable the reader to form some idea of the extremely tedious process of velvet-weaving. The wire requires to be inserted and cut out again fifty-five times in the space of an inch, that is, a strip of velvet one inch broad, and whose length is equal to that of the breadth of the piece. And when we consider that the threads of the woof are of different degrees of fineness, rendering two shuttles necessary, which must be exchanged at frequent but unequal intervals, we can form an estimate of the incessant care and vigilance necessary on the part of the weaver in conducting these various operations. Much caution and dexterity, too, are required in cutting the loops: for, however simple the operation of passing a knife along a straight edge may appear, yet this part of the process can only be acquired by long practice; for the smallest deviation from the straight line would injure the appearance of the velvet. The weaver being thus occupied in so many distinct operations in rapid succession, finds his work to increase very slowly, and he has been very industrious if, at the end of a long day's work, he has woven a yard of plain velvet.

It will be seen from the above statement that the richness of velvet depends upon the number of threads forming the pile: the degrees of richness are accordingly indicated in this way, and the manufacturer speaks of velvet of two, four, or six threads, according to the number of pile-threads inserted. The striped velvet, with which waistcoats are sometimes made, is produced by leaving uncut a number of the pile-loops.

The peculiarly rich effect of velvet results from the absorption of the light which falls upon its surface, and hence, too, arises the sombre effect when much of this substance meets the eye.

Brocade. In the early part of the last century a favourite but costly stuff for dresses was formed of gold, silver, and silken threads, enriched with flowered ornaments of the same materials: this was called *brocade.* At the present day, however, all stuffs, grograms, satins, taffetas, and lustrings are called *brocades,* if they are adorned with flowers or other figures.

In the preparation of gold brocade many ingenious devices have been resorted to for diminishing the costliness

of the article, by employing as small a quantity as possible of the precious metals. In the preparation of the threads for the brocade, a flattened silver-gilt wire or riband was spun on silk which had been previously dyed as near as possible of a gold colour; and the chief merit in preparing gold threads was so to regulate the convolutions of the metallic covering of the silk, that its edges should be in close contact, and form a continuous casing without any overlapping or interstices.

In all manufactures a great demand for an article is a sufficient stimulus to ingenious persons to contrive the very best possible methods for its production; and accordingly, we find that at the time when gold brocade was much in request, the manufacture of the thread (upon which branch the value of the brocade greatly depended) was in a state of excellence; and some manufacturers were so jealous of their skill as to keep their processes strictly secret. Among others, there existed at Milan a large manufactory, where, by a secret process, flattened wire, gilt on one side only, was made. Nuremburg, the great toy-shop of Europe, furnished an inferior description of thread, made by spinning gilt-copper wire on flaxen or hempen threads. The economical Chinese employed slips of gilt-paper twisted upon silk:—sometimes they even twisted the paper without any internal support, into long spiral rolls and introduced it into their dresses. But as these golden tissues were by no means permanent when worn about the person, the Chinese confined their use chiefly to the tapestries and internal decorations of their houses.

About the thirteenth century a very flourishing manufacture of brocades existed at Lucca; but in the year 1310 the artisans being oppressed by the government, fled to Venice, where they were encouraged to resume their trade, and for a long period they continued to carry it on with considerable success.

The Venetians invented a new form of brocade which they named *damasquitte*. Although it contained no more than half the quantity of gold and silver usually employed in making brocade, yet its appearance was far more costly and beautiful. The flattened wires were not placed so closely together on the silk threads, and the number of these threads in weaving was diminished. But the great secret of the economy seems to consist in passing the manufactured stuffs in a peculiar manner between rollers with great pressure, so as partially to crush the wire

threads; by this means the ornamental pattern appeared like one entire brilliant surface of gold or silver.

This process was long kept a secret; but about the middle of the last century the spirit of commercial rivalry prompted the French Government to attempt a similar manufacture. In this attempt they were assisted by M. Vaucanson, so celebrated for his automatic achievements, who erected machinery at Lyons, and presented an account of his proceedings to the French Academy in the year 1757.

The rollers employed by M. Vaucanson were, the upper one of wood, and the lower one of copper, the latter being made hollow, for the insertion of iron heaters. In the early attempts it was found that the united force of ten men was scarcely sufficient so to work the rollers as to extend the plating of the wire-threads; and the great amount of force so deranged the machinery in which the rollers were placed, that the effects of pressure on the cloth were always varying. Among many other inconveniences, the wooden rollers were constantly splitting or warping, in consequence of the mode of forcing the rollers together. M. Vaucanson, therefore, contrived a method whereby the pressure should always adjust itself to any inequalities in the stuff, or in the bearings of the machine. The axis of the copper roller he made to turn between anti-friction rollers, while the wooden roller was forced upwards by levers at the ends. Each lever had its short arm supported on the frame of the machine, and the long arm was drawn up by an iron rod communicating with the short arm of a horizontal lever, to which at its long arm was hung a weight; and these levers were so proportioned that thirty pounds only would produce a pressure between the rollers equal to 17,000 or 18,000 pounds. This force was found sufficient, and it was so effectual that the efforts of four men in turning the rollers answered the purpose better than ten men in the former case.

The copper roller was heated by the insertion of four red-hot iron bars. After two or three pieces of cloth had been rolled, a fresh wooden roller was employed, since the heat, if long continued, was sure to split it. The heated wooden roller was wrapped, as soon as it was removed, in cloths, and placed in an atmosphere from which it might acquire moisture. The heat and pressure thus employed to extend the gilding were found greatly to improve the brilliancy of white and yellow silks, but to impair that of crimson, green, and other colours.

It will be seen, from the above statement, that brocade was a very costly article of dress; not only from the amount of precious metal employed, and the tedious and expensive mode of manufacture, but also from its evanescent nature. A brocade dress was very liable to become tarnished; when such was the case, the mode of washing was also costly. A soft brush, dipped in warm spirits of wine, is said to have been the only method of restoring tarnished brocade. Brocade powders were in vogue at the time this sumptuous dress was in fashion, but they were ineffectual, because, from the extreme thinness of the metal, it was easily scratched or worn away by the friction even of the most impalpable powder.

Brocade continued to be used in ornamenting drawing-room furniture, long after it had ceased to adorn the persons of beaux and belles. In 1798 some brocade chair-bottoms, for Carlton House, were produced at Spitalfields, and are said to be still in existence. There is no doubt that should the vane of that weathercock, Fashion, again point out gold and silver brocade as a desirable article of attire, our modern manufactures would soon equal, if not surpass, the costliest productions of former days. To those who are anxious for such a result let us recommend the remarks of the *Spectator*, which, though written a hundred and thirty years ago, are still applicable, because they refer to one of the weaknesses of human nature.

"A furbelow of precious stones, a hat buttoned with a diamond, a brocade waistcoat or gown, are standing topics of conversation. In short, they only consider the drapery of the species, and never cast away a thought on those ornaments of the mind, that make persons illustrious in themselves and useful to others. When persons are thus perpetually dazzling one another's imaginations, and filling their heads with nothing but colours, it is no wonder that they are more attentive to the superficial parts of life than the solid and substantial blessings of it."

Damask is a term generally applied, not so much to the weaving of threads of different colours, as to the formation of a pattern by a peculiar mode of weaving threads of the same colour. Table-cloths present a beautiful instance of this in linen; and the furniture employed frequently for beds, windows, sofas, and chairs, illustrates the same peculiarity in silk. Such fabrics are not much used at the present day for ladies' dresses.

Gauze is a material in which the smallest quantity of silk is employed for a given size of woven fabric. This is

effected by having very perceptible interstices between the threads; and as these interstices would much weaken the gauze if woven in the usual way, the threads are, by a peculiar arrangement of the loom, made to cross and loop over each other, something like the threads of a net. This entwining of the threads may easily be seen on looking at a piece of gauze.

Bombazine is a mixture of silk and worsted: the former in the warp, and the latter in the weft. Originally these were made only black, and used for mourning; but at the present day they are woven of a grayish colour, and afterwards dyed to any other that may be desired. The manufacture has been almost wholly removed from Spitalfields to Norwich.

Poplin and *lustre* are the names for two other kinds of goods in which silk and worsted are combined; but the proportion of silk is larger than in bombazine. Norwich shawls have within a few years risen to great celebrity: they are composed of silk mixed either with cotton or with worsted.

Persian, sarsenet, Gros-de-Naples, ducape, &c., are the names of many varieties of silk goods which do not differ in the mode of manufacture, but in the quality or quantity of the material used in them. Persian is a very inferior and flimsy kind of silk used for the commonest purposes where strength is not required. Sarsenet is somewhat stouter, and used for better purposes. Gros-de-Naples is much superior to both of them, being made with better silk, and a greater number of threads being woven in a given space. Ducape is also a stout silk, but of softer texture than Gros-de-Naples.

Levantine, is a stout twilled silk. *Gros-des-Indes* is a silk of which the weft is composed alternately of different colours, so that the material appears striped in the direction of the width.

Satin is a twilled silk, which owes its peculiar lustre to the number of threads of warp which are passed *over* by the weft, before it passes *under* one of them: sometimes the thread passes over as many as eight warp-threads before it interlaces, and thereby presents a glossy surface to the eye. When it comes out of the loom, satin frequently presents a slight degree of roughness or flossiness, on account of the comparative infrequency of the interlacings of the weft with the warp. To remove this, the satin is passed between heated rollers, by which the face is smoothed down, and the surface receives that beautiful lustre which belongs so peculiarly to satin.

Crape is a peculiar, transparent, and *wrinkled* kind of silk goods. It is woven with very thin threads, in a slight and somewhat open manner; and is then stiffened with gum in such a manner as partially to untwist the fibres of the threads forming the warp and weft, giving them an irregularity of appearance which distinguishes crape. The separation of the fibres in this manner is attended with the effect of removing everything like *gloss* from the surface: a sombreness is thus produced, which is perhaps the chief reason why crape is so much used for *mourning*.

There are numerous other silken fabrics; but they all belong to one or other of the kinds here described, so we will not enter into further description of them.

Bleaching.

The silk, on which all the preceding processes have been performed, is, in its natural state, of a golden yellow colour, arising from the gum with which the insect lubricates it. In order that the silk should appear white, or that it should be able to receive certain dyes, it is necessary to bleach it, which is generally done before it is woven.

The general mode of bleaching is stated by Dr. Ure to be as follows:—A quantity of water is put into a boiler over a fire, and for every hundred pounds of silk, thirty pounds of very fine soap are dissolved. The solution is generally boiled; but before the silk is put into it, the heat must be lowered to about ninety degrees, and it must be kept at this temperature during the process. The silks are to be hung in the liquor in rods or frames, and left till the gum is sufficiently removed; care being taken to alter their position occasionally, so that every part may be exposed to the action of the bath. When perfectly ungummed, they are flexible, and of a dull white hue; in this state they are to be wrung, in order to clear them of the soapy water; they are then shaken, and put into coarse linen bags, in parcels of from twenty to thirty pounds each. These bags are now to be steeped in a fresh bath, which is prepared in a manner and proportion very similar to the former, except that the quantity of soap may be somewhat diminished. The silk is next boiled for two or three hours, care being taken to keep the bags from adhering to the bottom of the boiler, by frequently stirring them with a stick.

For silk that is to be dyed, the first steeping is unneces-

sary, and the present boiling only is employed, a greater quantity of soap being used in proportion to the fineness of the colour to be dyed. After boiling, the silk is wrung as before, and then washed thoroughly in a stream of water; they are then examined, and if it appears that they are not sufficiently scoured, they are again put into the bath.

The white silk usually sold has a bluish shade. This is imparted by dissolving a pound and a half of fine soap in about ninety gallons of water, in which a small quantity of litmus or indigo has been dissolved. The bath is heated to about ninety degrees, and the silk is passed through it over rods or reels till it has acquired the requisite shade. Being taken out, it is wrung and dried.

For gauze, blonde, and other silken fabrics which are required to have a certain degree of stiffness, the bleaching is effected without removing all the gum from the silk.

Dyeing.

The process of dyeing silk is so much like that of dyeing cotton, that we need not add much to what has been already said on the subject of dyeing. We will, however, give one instance,—namely, that of dyeing silk crimson by means of cochineal.

The first process is *aluming*. Forty or fifty pounds of alum, previously dissolved in warm water, are mixed in a vat with forty or fifty buckets of water; and to prevent the crystallization of the alum, the solution is carefully stirred. The silk, being washed to separate any remains of soap from the bleaching, is immersed in this alum liquor, and at the end of eight or nine hours it is wrung out and washed in a stream of water. These proportions of course apply to a large quantity of silk.

The alumed silk is then put into a dye or bath thus prepared. A boiler is two-thirds filled with water, to which is added, when it boils, about an ounce of powdered white galls for every pound of silk. When it has boiled for a few moments, from two to three ounces of cochineal for every pound of silk are put in, and afterwards one ounce of tartar to every pound of cochineal. When the tartar is dissolved, one ounce of solution of tin is added for every ounce of tartar. When these ingredients are mixed together, the boiler is filled up with cold water, so as to have about ten quarts to every pound of silk. In

this the silk is now immersed, and turned about till it assumes a uniform colour. The fire is then increased, and the bath is kept boiling for two hours, the silk being turned occasionally. The fire is afterwards put out, and the silk again put into the bath, where it is allowed to remain for a few hours longer. It is then taken out, washed in a stream, wrung, and dried.

By processes more or less resembling this, any other colour is imparted to silk.

Substitutes for Silk.

The extensive use which is made of silk goods, and the value they have acquired in all civilized countries, have led to various experiments amongst ingenious persons, for the purpose of ascertaining whether a substance or substances might not be obtained from other sources, which should answer the same purpose as that to which the production of the silk-worm is at present so widely applied. Two of these attempts we may here notice.

Silk from Spiders. At the beginning of the last century a method was discovered in France of obtaining silk from the nests of some species of spiders. It is well known that besides the ordinary web of spiders, there is a small silky bag spun by particular species for the protection of their eggs. These bags may often be found in the corners of windows, under the eaves of houses, in cellars and vaults, in hollow trees, and in similar protected situations, where neither wind nor rain can reach them. They are much stronger and more durable in their texture than the webs formed to entrap the spider's prey; and in shape they resemble the silk-worm's cocoon when it is prepared for the distaff. When first formed, these spiders' bags are of a grey colour, but by exposure to the air and dust they soon acquire a blackish hue.

It was from the bags thus formed by spiders around their eggs that silk was procured, at the time above stated, by a M. Bon, whose dissertation on the mode of obtaining and preparing the silk is extremely interesting.

The method of classing spiders is usually according to their different colours, whether black, brown, yellow, &c., or sometimes by the number and arrangement of their eyes, some spiders possessing as many as ten of these organs,—others eight,—and others again six. M. Bon notices only two kinds as silk-producing spiders, and dis-

tinguishes them from each other, as having either long or short legs, the latter producing the finest quality of raw silk.

The spider is provided with fine papillæ, or small nipples, placed in the hinder part of its body, which are like so many wire-drawing irons, to form and mould a glutinous liquor, with which the insect is provided, and which, on being drawn out through these papillæ, and exposed to the air, immediately dries, and forms silk. Each of these papillæ consists of a number of smaller ones, so minute as not to be discernible, and only made evident by the effects produced. Several distinct threads issue from each, the number of which, on account of their extreme fineness, cannot be counted with any accuracy. The principal papillæ are five in number; but these being made up of innumerable smaller ones, and each of these smaller ones emitting a beautifully fine thread, the total number of threads uniting to form the filament used by the spider is astonishingly great. By this beautiful arrangement the threads can be applied in a greater or less number, according to the strength required in the spider's work; and when all these threads unite and form one, as they do at the distance of about the tenth of an inch from the body of the insect, the tenacity of the principal thread is increased, and its strength is greater than if it were not thus composed of many individual filaments.

A quantity of the spiders' bags were first collected by M. Bon, and then treated in the following manner. Twelve or thirteen ounces of the bags were beaten with the hand or by a stick, until they be entirely freed from dust. They were next washed in warm water, which was continually changed, until it no longer became clouded or discoloured by the bags under process. After this they were steeped in a large quantity of water, wherein soap, saltpetre, and gum-arabic had been dissolved. The whole was then set to boil over a gentle fire, during three hours, after which the bags were rinsed in clear warm water, to discharge the soap. They were then set out to dry, during several days, and the carding operation was then performed, with cards differing from the usual sort only in being much finer. Thus was a peculiar ash-coloured silk obtained, which was spun without difficulty, which took readily all kinds of dyes, and might have been wrought into any kind of silken fabric. M. Bon had stockings and gloves made from it, some of which he presented to the Royal Academy of Paris, and others to the Royal Society of London.

The silk was affirmed by M. Bon to be stronger and finer than the common sort, and, according to his statement, spiders were much more productive than silkworms, and there were besides the following advantages relating to them; spiders hatch spontaneously, without any care, in the months of August and September, the old spiders dying soon after they have laid their eggs: the young ones live for ten or twelve months without food, and continue in their bags without growing, until the hot weather, by putting their viscid juices in motion, induces them to come forth, spin, and run about in search of food.

The only obstacle, therefore, to establishing a considerable manufacture from these spider-bags, that is, the difficulty of obtaining them in sufficient abundance, was attempted to be obviated by breeding young spiders in convenient apartments on a large scale. M. Bon commissioned a number of persons to collect and bring to him all the short-legged spiders they could possibly obtain. These, as he received them, he inclosed in paper coffins, or in pots covered with papers, which papers, as well as the coffins, were pricked over their surface with pinholes, to admit air to the prisoners. The spiders were duly fed with flies, and after some time it was found on inspection that the greater part of them had formed their nests. It was contended that these nests afforded much more silk in proportion to their weight than those of the silk-worm, in proof of which it was asserted, that thirteen ounces yielded nearly four ounces of pure silk, two ounces of which were sufficient to make a pair of stockings; whereas, stockings made of common silk weighed seven or eight ounces. It had been objected by some persons that the spider was venomous, and that this evil quality extended to the silk obtained from it. M. Bon, in answer to this prejudice, affirmed that he had several times been bitten by spiders, when no injury had followed; and that the silk, so far from being pernicious, had been found useful in stanching and healing wounds, its natural gluten acting as a kind of balsam. Willing to extract every possible good from his favourite pursuit, he subjected the spider-silk to chemical analysis, and obtained from it a volatile salt, preparing which in the same manner used for the once celebrated *Guttæ Anglicanæ*, he produced drops, which, as he believed, possessed yet greater efficacy: he called this preparation *Montpellier drops*, and prescribed its use in all lethargic diseases.

M. Bon's establishment for the rearing of spiders, at

length engrossed a considerable share of public attention, and the subject being considered worthy of serious investigation, M. Reaumur was deputed by the Royal Academy of Paris to inquire into the merits of this new silken material. From the patient examinations of this eminent naturalist, it appeared that there were many serious objections to this plan; and such as were likely to prove quite insurmountable. In the first place, the natural fierceness of spiders renders them unfit to be bred together. On distributing four or five thousand of these insects into cells or companies of from fifty to one or two hundred, it was found that the larger spiders quickly killed and ate the smaller, so that in a short space of time, the cells were depopulated, scarcely more than one or two being found in each cell. In the next place, the silk of the spider is inferior to that of the silk-worm both in lustre and strength; and produces less material available for the purposes of the manufacture. The filament of the spider's-bag can only support a weight of thirty-six grains, while that of the silk-worm will sustain a weight of one hundred and fifty grains. Thus four or five threads of the spider must be brought together to equal one thread of the silk-worm, and as it is impossible that these should be applied so accurately over each other as not to leave little vacant spaces between them, the light is not equally reflected, and the lustre of the material is consequently inferior to that in which a solid thread is used. A third great disadvantage of the spider's silk is, that it cannot be wound off the ball like that of the silk-worm, but must necessarily be carded. By this latter process, its evenness, which contributes so materially to its lustre, is destroyed. That the silk articles produced from this material are really deficient in that glossy appearance which constitutes the principal beauty of silk, is fully confirmed by the testimony of M. le Hire, who, when the stockings of M. Bon were presented to the Royal Academy, immediately noticed their want of lustre. The last objection we shall notice against the raising of spiders, was one containing a calculation considered to be an exaggerated one, and it has been regretted that M. Reaumur should have taken extreme cases, if not actually improbable ones, to confute a system so little likely to advance itself as that of M. Bon. The advantages of the culture of silk from silk-worms when compared with its production from spiders, must be too apparent to every reflecting person to render it necessary to dwell long on them, or in any way to exaggerate them. M. Reaumur's comparison is to this effect. The largest cocoons weigh

four, and the smaller three grains each; spider-bags do not weigh above one grain each; and, after being cleared of their dust, have lost two-thirds of this weight; therefore the work of twelve spiders only equals that of one silk-worm; and a pound of spider silk would require for its production 27,648 insects. But as the bags are wholly the work of the females, who spin them as a deposit for their eggs, it follows that 55,296 spiders must be reared to yield one pound of silk: yet this will only be obtained from the best spiders; those large ones, ordinarily seen in gardens, &c., yielding not more than a twelfth part of the silk of the others. The work of 280 of these would therefore not yield more silk than the produce of one industrious silk-worm, and 663,552 of them would only furnish one pound of silk!

Silk from shell-fish. It is well known that the common edible mussel has the power of affixing itself to rocks, or to the shells of other mussels, with great firmness; and it has been ascertained that if the animal be accidentally torn from its hold, it has the power of replacing the threads of viscous matter, by which it thus attaches itself to different objects. The threads issue from the part of the shell where it naturally opens, and though each in itself is too delicate to possess much strength, yet the almost infinite number which are put forth, acting as so many small cables, keep the fish steady in its position, amidst all the power of the waves.

It is not to the mussel, however, that we refer as a silk-producing animal, but to a fish belonging to the same order, and in many respects resembling it. This is the *pinna*, a much larger fish than the mussel, its shell being sometimes found two feet long. The shell is bivalve, fragile, and furnished with a beard; the valves hinge without a tooth. The pinna like the mussel attaches itself to rocks; it is also found with the sharp end of its shell embedded in mud or sand, while the rest of the shell is left free to open in the water. Like the mussel, it has the power of spinning a viscid matter from its body; but the threads of the pinna are of great delicacy and beauty, being scarcely inferior to the single filament of the silk-worm. Both the pinna and the mussel are furnished with an organ, which is sometimes called a "tongue," sometimes a "foot," from its performing the offices of both those members. The latter of these offices is denied to it by some naturalists, who affirm that the pinna always remains in the same place; but though its powers of locomotion are very limited, yet it appears that an occasional change of situation is effected

by means of the organ we have alluded to. The extremity of the foot (as we may then call it) is fixed to some solid body, and being contracted in its length, the whole fish is necessarily drawn towards the spot where it has fixed itself; and by a repetition of these movements the animal arrives at its destination. The principal use of this organ, however, appears to be that of forming the *byssus*, which is the name given to the collection of threads by which the animal attaches itself at various points to some fixed spot. The formation of these threads is exceedingly curious and remarkable. They are not spun, like those of the spider and of the silk-worm, by being drawn out of the body, but they are cast in a mould, where they remain until they have acquired a certain degree of hardness and consistency. This mould is contained in the tongue of the animal, and forms a deep longitudinal furrow extending from the root to the circumference, having its sides so constructed as to fold over it, thereby making it into a canal. On the outside, this canal appears like a crack, being almost covered by the flesh on either side, but internally it is wider, and surrounded with circular fibres. The tongue is furnished with glands for the secretion of the peculiar liquor which forms the byssus, and from these it is poured into the canal, where it dries into a solid thread. When it has acquired sufficient tenacity the animal protrudes its foot, and applies and fixes the end of the thread to the surface of some object in its vicinity; the whole length of the canal is then suddenly opened, and the thread, which is fixed by one end to the tendon at the base of the foot, and by the other to the solid surface in question, is disengaged from its mould. The canal is now ready to receive another portion of the viscid secretion (which secretion exists in great abundance in this animal as well as in mussels), and the process is gone through as before. Thread after thread is thus formed, and applied in different directions round the shell; and it has been observed that the animal puts each thread in succession to the test, by swinging itself round and stretching it.

Thus, as Reaumur has observed, the workmanship of the land and sea animals, in forming the same production, is very different. Spiders, caterpillars, &c., form threads of any required length, by making the viscous liquor of which the filament is formed pass through fine perforations in the organ appointed for spinning. But the pinna and mussel form their threads in a mould situated within the organ, and which determines the length of each filament.

The work of the land animals therefore may be likened to that of the wire-drawer, while the labours of the sea animals may be compared to those of the founder who casts metals in a mould.

It was at first supposed that the pinna, as well as the mussel, had the power of transferring the threads thus formed from one spot to another; but subsequent observation has proved that wherever the animal takes up its position, there it must remain, unless by any accident the threads become severed, when it immediately begins to form others, and every fibre employed in fixing itself in a fresh situation is newly formed at the time it is required. The old threads appear quite useless, and have by way of experiment, been cut away from the body as close as was considered safe to the animal, when they were replaced by others, in as short a space of time as that employed by others not so mutilated. We learn from Poli, that the byssus in silk-producing fish is of the same structure as hair, and that at the extremity it is furnished with little cups, or suckers, by which it adheres firmly. In the pinna, the liquid matter is produced slowly, not more than four or five threads being formed in the course of a day and night. It is so exceedingly glutinous in its nature, that it will take a firm hold on the smoothest bodies. When the animal is disturbed in its operations, the threads are more hastily formed, and in consequence possess less strength than those which are produced at the ordinary rate.

The pinna is found on the coasts of Italy and Provence, and in the Indian Ocean. The largest and most remarkable species inhabits the Mediterranean Sea. It is exposed to the attacks of many enemies, especially of the cuttle-fish, which is its deadly foe. It is said (and the alleged fact has been celebrated in poetry) that the pinna is warned of approaching enemies by a faithful ally, which is ever at hand to afford its important services. This ally is a small animal of the crab kind, which takes refuge in the shell of the pinna, and compensates by its quickness of sight for the deficiency which the pinna, in common with the rest of its species, experiences in that respect. There is so much that appears fabulous in this reputed friendship of the pinna and the crab, that we willingly omit the several details, and proceed to notice the method to procure the byssus, and the uses to which that substance has been applied.

Although the fineness and beauty of this remarkable production is almost equal to that of the silk-worm's thread,

and has procured for the animal that forms it the common name of "the silk-worm of the sea," yet, when attached in filaments of almost innumerable extent to the rocks below the surface of the sea, it requires considerable force to disengage the tuft of threads. At Toulon an instrument called a *cramp* is employed by the fisherman for this purpose. This is an iron fork, with prongs eight feet in length, and six inches apart; the prongs are placed at right angles with the handle, the length of which is regulated by the depth of the water, and varies from fifteen to thirty feet. The pinnæ are seized, separated from the rock, and brought to the surface by means of this instrument.

It is uncertain whether the term "byssus," as used by the ancients, is always applicable to this particular substance. Aristotle speaks of byssus as being made from the beard of the pinna, and it is certain that this kind of silk was employed in the manufacture of certain fabrics in very ancient times. But it is also said that, by the name of byssus, the ancients meant indiscriminately any material that was spun, the quality of which was finer and more valuable than woollen threads. Sometimes the produce of the pinna is distinctly mentioned as being wrought into articles of dress; thus Procopius speaks of a robe composed of byssus of the pinna, as having been presented by the Roman emperor to the satraps of Armenia. This substance is evidently referred to by a writer of the year 1782, who says:—"The ancients had a manufacture of silk, and which about forty years ago was revived at Tarento and Regio in the kingdom of Naples. It consists of a strong brown silk, belonging to the same sort of shell, of which they make caps, gloves, stockings, waistcoats, &c., warmer than the woollen stuffs, and brighter than common silk. I have seen such kind of shells myself; I think it was of the pecten kind, but cannot be sure."

On the shores where the larger kind of pinnæ abound, the manufacture above alluded to is still carried on. At Palermo the silk is wrought into various articles of dress of a beautiful description. The stockings manufactured from this material are so fine, that a pair of them can be easily enclosed in a snuff-box of the ordinary size, and yet their warmth is such, that they are said to be more useful in gouty and rheumatic cases, than appropriate for common wear. This material will probably remain a rarity, except in the countries where it is produced, for it cannot be obtained in sufficient abundance to render it a commodity for exportation. In England it merely forms a curious

addition to some of our cabinets, while its existence as an article of manufacture is unknown.

When we consider that the silk-worm feeds on mulberry leaves, the spider on flies, and the pinna on fishes, it is a subject for admiration that, out of such dissimilar materials, the natural operations of the animal can produce filaments so nearly resembling one another.

The quantity of raw silk imported into England, chiefly from Piedmont, is supposed to amount in value to four millions sterling annually; and the exported manufactured silk goods to seven hundred thousand pounds annually.

Chapter VI.

HOSIERY.

It will no doubt readily appear to the reader, that a more satisfactory idea of the nature of clothing generally, will be obtained by considering the materials of which they are formed, than by treating separately of each article of dress. We have therefore described separately the four important materials, *cotton, wool, linen,* and *silk,* rather than the numerous articles of male and female attire which are made from them. The art of the tailor or the milliner can give almost any form to the woven productions; but those productions retain throughout the distinctive characters which originally belonged to them.

There are, however, a few instances in which the formation of some particular article of dress, of whatever material it may be made, is the work of a particular class of persons, and calls for peculiar machines, and peculiar kinds of ability in the workman. For example, the term *hosiery* generally implies coverings for the hands and feet; although the word "hose" itself is but another name for *stockings.* The reason why stockings and *gloves* are usually classed together, probably is, that they have been, to a great extent, produced by the same kind of *stitch,* or loop; and also that the hosier, who originally dealt in the more important article—stockings, came in time to sell gloves likewise.

Stockings.

Stockings, as articles of dress, cannot boast of so great antiquity as coverings for many other parts of the body; but whenever they were introduced, it is natural to suppose that they were made from the same kinds of woven fabrics as many other garments. But both stockings and gloves, in order to fit the form with that closeness which is necessary for convenience and neatness, should have a degree of elasticity which is not commonly possessed by woven materials. It is to this circumstance that we must refer the well-known practice of *knitting,* by which a fabric is produced possessing great elasticity; for the meshes or loops may be extended in any one direction, and contracted in another, to suit the form which the fabric is intended to cover.

When the art of knitting stockings was first practised, is not clearly known; but Professor Beckmann attributes it to the sixteenth century. Before that period, it appears that stockings were made of woven cloth, sewn up by a tailor, in the same way as other articles of clothing are made at the present day. Holinshed, who wrote about 1587, having to speak of Dr. Sands, afterwards Archbishop of York, gives some curious information respecting the stockings then in use:—"Dr. Sands, at his going to bed in Hurleston's house, he had a paire of hose newlie made, that were too long for him. For while he was in the Tower, a tailor was admitted to make him a pair of hose. One came in to him whose name was Benjamin, dwelling in Birchin Lane; he might not speak to him, or come to him to take measure of him, but onelie to look upon his leg; he made the hose, and they were two inches too long. These hose he prayed the good wife of the house to send to some tailor to cut his hose two inches shorter. The wife required the boy of the house to carrie them to the next tailor, which was Benjamin that made them. The boy required him to cut the hose. He said, I am not the maister's tailor. Saith the boy, Because ye are our next neighbour, and our maister's tailor dwelleth far off, I come to you. Benjamin took the hose, and looked upon them; he took his handlework in hand, and said, These are not thy maister's hose, but Dr. Sands', them I made in the Tower."

It appears that knitted stockings came into use about the reigns of Henry the Eighth and Elizabeth. Howell, in his *Institutions of General History*, 1680, says,—"Silk is now grown nigh as common as wool, and become the cloathing of those in the kitchen as well as the court; we wear it not only on our backs, but of late years on our legs and feet, and tread on that which formerly was of the same value with gold itself. Yet that magnificent and expensive prince, Henry VIII., wore ordinarily cloth hose, except there came from Spain, by great chance, a pair of silk stockins. King Edward, his son, was presented with a pair of long Spanish silk stockins by Thomas Gresham, his merchant, and the present was taken much notice of. Queen Elizabeth, in the third year of her reign, was presented by Mrs. Montagu, her silk woman, with a pair of black knit silk stockins, and thenceforth she never wore cloth any more."

There are many notices in old works to show that knitted stockings were about that period a great rarity. Stowe tells us, that the first stockings of knitted woollen yarn

seen in England, were worn by the Earl of Pembroke, in 1564;—a London apprentice having accidentally seen a similar pair of stockings in the shop of an Italian merchant, and which had been procured from Mantua, immediately went home and knitted a pair, which came into the possession of the earl. It appears probable that stockings of knitted silk were known in England earlier than those of knitted wool. But the words "hose" and "knit" are often used without expressing whether the material was silk or worsted. Thus Holinshed, speaking of a grand entertainment given by Henry the Eighth, says—"The King and some of the gentlemen had the upper part of their hosen, which was of blue and crimson, powdered with castels and sheafes of arrows of fine ducket gold, and the nether parts of scarlet, powdered with timbrels," &c.

There has been preserved an authentic and curious household book, kept during the life of Sir Thomas L'Estrange, by his lady, Anne, daughter of the Lord Vaux. This family lived at Hunstanton, in Norfolk, during the reign of Henry the Eighth; and among other entries in the book, are the following:—

"1533.	35 Hen. 8.	7 Sept.	Peyd for	4 peyr of knitt hose	viiis.
1538.	80 Hen. 8.	3 Oct.	"	2 peyr of knitt hose	is."

The first of these were for Sir Thomas himself; the second, for his children.

Holinshed further tells us, that "the bark of the alder is not unprofitable to die black withall, and therefore much used by our countrie wives in colouring their knit hosen." And again, when Queen Elizabeth visited Norwich, in 1579, she saw some of the inhabitants thus employed:—"Upon the stage there stood at the one end eight small women children, spinning worsted yarn, and at the other as manie knitting of worsted yarn hose."

It has been thought that the knitting of stockings was practised in Germany earlier than in England. An account has been handed down of a duchess of Pomerania, who died in 1417, and who, when she could no longer sew or embroider, used to amuse herself with knitting, repeating to her daughter meanwhile the following rhymes:—

"Nicht beten, gern spatzieren gehn,
Oft im Fenster und vorm Spiegel stehn,
Fiel geredet, und wenig gethan,
Mein kind, da ist nichts Fettes an."

(Never to pray, to be fond of walking, to stand often at the window and before the looking-glass, to talk much and to do little,—is not, my child, the way to be rich.)

But this early use of knitting in Germany has been doubted, some thinking that it was not known till the following century.

It is, however, sufficient for our purpose to know that knitting has continued in use for three centuries as a mode of making hosiery. At the present day it is but little practised, except in the most secluded districts, or as a matter of amusement; for, small as is the pecuniary value of female labour, generally speaking, there are many employments for the female peasantry much more advantageous than that of knitting stockings, since machine-made hose have become so universal.

It is scarcely necessary for us to say what knitting is. Most persons have some idea of the process, and those who have not can scarcely gain it from a written description. Suffice it to say, that by means of yarn, and two, three, or four long needles called knitting-needles, the knitter contrives to make a series of loops or meshes out of one continuous thread, which loops become linked among one another like chain-work. A fabric is thus formed which differs very considerably from those which have been woven, but which possesses considerable strength, and a far greater degree of elasticity than woven fabrics generally.

Still knitting is a slow process; a considerable time is consumed in making one pair of stockings by such means; and it is not surprising that attempts should have been made to bring machinery to aid the fingers. This has been done by the invention of what is called the *stocking-frame*, a beautiful specimen of mechanism, the history of which involves something more of romance than is common in these matters.

One writer relates the origin of the stocking-loom to have been this:—A student of Oxford was so imprudent as to marry at an early period, without money and without income. His young wife, however, was able to procure the necessaries of life by knitting. But as their increasing family was likely soon to render this insufficient, the husband invented a machine by which knitting could be performed in a more speedy and profitable manner. Having thus completed a stocking-loom, he became by its means a man of considerable wealth.

Savary, a French writer, gives the honour to a countryman of his. He says, that when the Frenchman invented the stocking-loom, he found that he was not able to obtain the exclusive privilege of using it in his own country, and therefore took it to England. The utility of the machine being soon discovered, it was forbidden, under pain of

death, to carry the loom, or a model of it, out of the kingdom. But another Frenchman having seen the loom, its form made so deep an impression on his memory, that, on his return, he copied it exactly; and from this loom all the others used in France and Holland were constructed.

Another story, equally calculated to give the honour of the discovery to a Frenchman, was related by an apothecary, at the *Hotel-Dieu*, at Paris. This person declared that the inventor was a journeyman locksmith of Lower Normandy, who gave a pair of silk stockings, his own workmanship, to Colbert, in order that they might be presented to Louis XIV.; but, as the *marchands bonnetiers*, who dealt in articles knit according to the old manner, caused several loops of these stockings to be cut by some of the servants at court, whom they had bribed for that purpose, they did not meet with approbation. The inventor was so grieved by this disappointment, that he sold the loom to an Englishman, and died an old man in the *Hotel-Dieu*, where the apothecary became acquainted with him.

But all these stories are now proved to be erroneous, the real inventor having been one William Lee. About the year 1656, a number of stocking-knitters of Nottingham presented a petition to Oliver Cromwell, to constitute them a guild or corporate body, on account of the importance which the invention of a stocking-machine had given to their trade. The petitioners say that their trade "is properly styled *frame-work knitting*, because it is direct and absolute knit-work in the stitches thereof, nothing different therein from the common way of knitting (not much more anciently for publick use practised in this nation than this), but only in the numbers of needles at an instant working in this, more than in the other by a hundred to one, set in an engine or frame composed of above two thousand pieces of smith's, joiner's, and turner's work, after so artificial and exact a manner, that, by the judgment of all beholders, it far excels in the ingenuity, curiosity, and subtilty of the invention and contexture, all other frames or instruments of manufacture in use in any known part of the world."

The petitioners proceed to state, that the stocking-frame was invented about fifty years previously by William Lee. The particulars of this invention we will give in the words of Deering, who wrote a *History of Nottingham*, about a century ago. "The inventor of the stocking-frame was one Mr. William Lee, M.A., of St. John's College, Cambridge, born at Woodborough, a village in Nottinghamshire, about seven miles from the town of Nottingham.

He was heir to a pretty freehold estate: of whom the traditional story says: That he was deeply in love with a young townswoman of his, whom he courted for a wife; but she, whenever he went to visit her, seemed always more mindful of her knitting than the addresses of her admirer. This slight created such an aversion in Mr. Lee against knitting by hand, that he contrived to contrive a machine that should turn out work enough to render the common knitting a gainless employment. Accordingly he set about it, and having an excellent mechanical head, he brought his design to bear, in the year 1589. After he had worked awhile, he taught his brother and several relations to work under him. Having for some years practised this his new art at Calverton, a village about five miles from Nottingham, either himself or his brother James worked before Queen Elizabeth, in order to show an experiment of this kind of workmanship, offering at the same time this discovery to his countrymen, who, instead of accepting the offer, despised him, and discouraged his invention. Being thus discountenanced by his native country, and soon after invited over to France, with promise of great rewards, privileges, and honours, by King Henry IV., he embraced the seeming fair opportunity, and went himself, with nine workmen, his servants, and as many frames, to the city of Roan (Rouen?) in Normandy, where they wrought with so great applause from the French, that in all likelihood the trade was to have been settled in that country for ever, had not the sudden murder of that monarch disappointed Mr. Lee of his expected grant of privilege, and the succeeding intestine troubles of that kingdom, delayed his renewed suit, and at last frustrated all his hopes; at which, seized with grief, he ended his life at Paris. After his death, seven of his workmen (being left to shift for themselves) returned with their frames to England, two only remaining behind."

It is now believed that the foregoing account is, in its substantial details, correct. In the Stocking-Weavers' Hall at London, is an old painting, in which Lee is represented pointing out his loom to a female knitter who is standing near him, and below it is inscribed the date of the invention, 1589.

The seven men who returned from France, together with an apprentice named Aston, whom he had left behind in England, now established the stocking-trade at Nottingham, and by degrees so extended it, that it has ever since been considered the staple manufacture of that town.

A few years after this re-establishment of the manufac-

ture in England, the Venetian Ambassador, Antonio Correr, persuaded an apprentice, Henry Mead, by the promise of five hundred pounds, to go with a loom to Venice for a stated time, and to teach the use of it to some persons appointed for the purpose. Mead met with a favourable reception in the city, and his workmanship was much admired; but the loom becoming deranged, and no person at Venice being able to repair it, when the time of his agreement was expired, he returned to England. The Venetians had not resolution enough to continue the attempt; and sent the damaged loom, together with some bad imitations of it, to London, where they were sold for a mere trifle.

An attempt to introduce the loom into Holland failed in a somewhat similar manner. Abraham Jones, who understood stocking-weaving and the construction of the loom, though never regularly taught, went with some assistants to Amsterdam, where he worked on his own account two or three years, till he and his people were carried off by a contagious disease. As no one could now use the looms, they were sent to London, and sold for a low price.

It was a remarkable exception to the general train of events connected with the invention of machinery, that for one hundred and seventy years scarcely any change or improvement was made in the stocking-frame: this speaks strongly in favour of the excellence of Lee's invention. About the year 1759, Mr. Jedediah Strutt, of Derby, made an improvement in the machine, by which it was rendered capable of producing *ribbed* stockings. Soon after this, a train of improvements and additions enabled manufacturers to produce fabrics in imitation of pillow-lace; point-net, pin-net, warp-net, and bobbin-net, were the successive results of these improvements. But that form of the machine which is employed for the manufacture of stockings does not, at the present day, differ very greatly from the one invented by Lee two hundred and fifty years ago.

To understand the action of this intricate machine, even with the aid of wood-cuts, is extremely difficult: we shall therefore not attempt a minute description of it. The reader is aware that stockings are made from silk, cotton, and worsted. The yarn to form the stocking is not arranged in the warp-and-weft manner, but, by the aid of a number of fine needles arranged in a row, it is caught up into loops, and the loops are linked among one another in such a manner as to form an extended fabric.

Worsted stockings are chiefly made in Leicestershire; silk in Derby and Nottingham; and cotton at Derby, Not-

tingham, Hinkley, and Tewkesbury. There are about 33,000 stocking-frames in England, which produce annually 3,400,000 dozen pairs of cotton stockings, about 1,000,000 dozen of worsted, and 90,000 dozen of silk; for all of which about 8,000,000 pounds' weight of raw material is required. The change in the value of the material is thus estimated,—that in the raw state they are worth about six hundred thousand pounds, and when manufactured into stockings, about two millions sterling.

Gloves.

When we draw upon our hands these comfortable and useful articles, we are apt to think them an invention of *modern* luxury or convenience, and need to be reminded that they were much in use in very early times. We may, therefore, briefly consider this subject with reference both to the ancient and to the modern condition of the world.

In the book of Ruth (ch. iv., ver. 7,) the custom is noticed of a man taking off his *shoe*, and giving it to his neighbour, as a pledge for redeeming or changing any thing. The events of the book of Ruth belong to the year 1245 B. C., and the word in this text usually translated *shoe* by the Chaldee paraphrast, is in this place rendered *glove*. A like supposition is offered with regard to the passage at Psalm cviii. 9, where the royal prophet declares he will cast his *shoe* over Edom. The expression occurs likewise at Psalm lx. 8, and both these religious hymns were composed about the year 1040 B. C. Casaubon is of opinion that *gloves* were worn by the Chaldeans, from the word used in the book of Ruth being explained in the Talmud Lexicon by *the clothing of the hand*.

Xenophon tells us that the ancient Persians used gloves: when describing their manners, he cites this as a proof of their effeminacy. Homer describes Laertes, the father of Ulysses, as working in his garden with gloves on his hands, to secure them from the thorns. Now Homer lived about 900, and Xenophon about 400 years B. C.

Varro, who lived in the time of Cicero, tells us of their longstanding use among the Romans. He wrote a book on *Rural Business*, wherein he tells us that olives gathered with the naked hand are preferable to those gathered with gloves. Athenæus speaks of a celebrated glutton, who always came to table with gloves on his hands, that he might be able to handle and eat the meat while hot, and devour more than the rest of the company.

Thus far it would seem that gloves were not so much an ordinary covering, as a protection used for specific purposes: the use of them among the ancients was therefore not so common as among the moderns. In a hot climate the wearing of gloves implies a considerable degree of effeminacy, so that the early use of gloves can be more clearly traced among northern nations. When the primitive simplicity of Rome had passed away, the philosophers were found to rail at the prevailing use of gloves. Pliny the younger informs us, in his account of his uncle's journey to Vesuvius, that his secretary sat by him, ready to write down anything remarkable that occurred; and that he had gloves on his hands, that the coldness of the weather might not impede his business.

It is curious to find that Musonius, a philosopher who lived at the close of the first century of Christianity, among other invectives against the corruption of the age, says:—"It is shameful that persons in perfect health should clothe their hands and feet with soft and hairy coverings."

The use of these articles kept on progressing, until, at the beginning of the ninth century after Christ, the Church began to lay down regulations for this part of dress. At the Council of Aix it was ordained that the monks should wear gloves made of sheep-skin. Serius tells us a Romish legend respecting St. Gudula, the patroness of Brussels, that, as she was praying in a church, without her shoes, the priest compassionately put his gloves under her feet; but she threw them away, and they miraculously hung in the air for the space of an hour,—whether in compliment to the saint or the priest does not appear.

Gloves have been used on several great and solemn occasions, as in the ceremony of investitures, in bestowing lands, or in conferring dignities. Giving possession by delivering a glove has prevailed in several parts of Christendom in later ages. Bishops have been instituted to their sees by means of the glove; and they were thought so necessary a part of the episcopal habit, that when some abbots of France presumed to wear gloves, the Council of Poitiers interposed, and forbade them, as peculiar to the bishop alone.

The custom of blessing gloves at the coronation of the kings of France is a remnant of the Eastern practice of investiture by a glove. The influence of this notion is exhibited in the case of the unfortunate Conradin, who was deprived of his crown and life by Charles of Anjou. When he had mounted the scaffold, the injured prince lamented his hard fate, asserted his right to the crown, and, as a

token of investiture, threw his glove among the crowd, entreating that it might be conveyed to some of his relations, who would avenge his death. It was taken up by a knight, and carried to Peter, king of Arragon, who, in virtue of this glove, was afterwards crowned at Palermo, in Sicily.

To deprive a person of his gloves was a mark of divesting or depriving him of his office. When the Governor of Carlisle, in the reign of Edward the Second, was impeached of holding a correspondence with the Scots, and was condemned to die as a traitor, his spurs were cut off with a hatchet, and his *gloves* and shoes were taken off.

In former ages, the throwing down of a glove constituted a challenge, which he accepted who took it up. Such sort of single combat was meant as a trial of innocence, and was likewise often practised for deciding rights and property. This custom was continued down to the reign of Queen Elizabeth. A dispute concerning some lands in the county of Kent was appointed to be settled by duel in Tothill-fields, in the year 1571. The plaintiffs had appeared in court, and demanded single combat. One of them threw down his glove, which the other party immediately taking up, carried off on the point of his sword, and the day of fighting was appointed: but this affair was adjusted by the judicious interference of the queen.

In Germany, on receiving an affront, to send a glove to the offending party is a challenge to a duel; and this method of daring a person to fight, has been in use even in this country, where local circumstances made feuds and animosities common; as the following narration will show.

Bernard Gilpin was a faithful ecclesiastic of the sixteenth century, whose spiritual work was carried on among the northern borderers. On a certain Sunday going to preach in those parts wherein deadly feuds prevailed, he observed a glove hanging up on high in the church. He demanded of the sexton what it meant, and why it hung there. The sexton answered that it was a glove which one of the parishioners had hung up there as a challenge to his enemy; signifying thereby, that he was ready to enter into combat hand to hand, with him, or any one else, who should dare to take the glove down. Mr. Gilpin requested the sexton to take it down. "Not I, sir," replied he, "I dare do no such thing." Then Mr. Gilpin, calling for a long staff, took down the glove himself, and put it in his bosom. By and by, when the people came to church, and Mr. Gilpin in due time went up into the pulpit, he in his sermon reproved the barbarous custom of challenges, and especially the custom which they had of making challenges by the hang-

ing up of a glove. "I hear," said he, "that there is one amongst you, who even in this sacred place, hath hanged up a glove to this purpose, and threateneth to enter into combat with whosoever shall take it down. Behold, I have taken it down myself." Then, plucking out the glove, he showed it openly, and, inveighing against such practices in any man that professed himself a Christian, endeavoured to persuade them to the practice of mutual love and charity.

At the coronation of George IV., in 1821, the ceremony was performed, probably for the last time, of challenging by a glove any one to dispute the right of the sovereign to the crown. His majesty's champion entered Westminster Hall completely armed and mounted, and threw down his glove.

Gloves were also particularly used for carrying the hawk, which princes and other great men, formerly took much pleasure in doing; so that some of them have chosen to be represented in this attitude.

Judges were formerly forbidden to wear gloves on the bench; but both they and the rest of the court receive gloves from the sheriffs, whenever the session or assize concludes without any one receiving sentence of death: this is a custom of great antiquity.

It appears likewise to have been a custom not to enter the stables of princes, or other great men, without pulling off the gloves, under the penalty of forfeiting them, or of redeeming them by a fee to the servants. This custom is likewise observed in some places at the death of the stag; in which case, if the gloves are not taken off, they are redeemed by money given to the keepers and huntsmen. The King of France always pulled off one of his gloves on this occasion; but the reason for this custom seems to be lost.

Gloves are usually presented at weddings and funerals. By the term *glove-money* is meant money given to servants to buy gloves; this was done because they were more expensive formerly than they are now. Gloves were also a customary new-year's gift. When Sir Thomas More, as lord chancellor, decreed in favour of Mrs. Croaker against Lord Arundel, she, on the following new-year's day, in token of her gratitude, presented him with a pair of gloves containing forty angels. "It would be against good manners," said the chancellor, "to forsake a gentlewoman's new-year's gift, and I accept the gloves; their *lining* you will be pleased otherwise to bestow."

A person in company, who first sees the new moon, and

thereupon salutes his fair companion, has a claim upon her for a pair of new gloves. This custom is peculiar to some of the northern parts of England.

It appears that gloves did not form part of the female dress until after the Reformation. In the time of Queen Anne they were richly worked and embroidered.

Some of the oldest gloves extant exist in the Denny family. At the sale of the Earl of Arran's goods, April 6, 1759, the gloves given by Henry VIII. to Sir Anthony Denny were sold for 38*l.* 17*s.*; those given by James I. to his son Edward Denny, for 22*l.* 4*s.*; the mittens given by Queen Elizabeth to Sir Edward Denny's lady, 25*l.* 4*s.*; all which were bought for Sir Thomas Denny of Ireland, who was descended in a direct line from the great Sir Anthony Denny, one of the executors of the will of Henry VIII.

Gloves are made principally of leather, silk, cotton, and worsted. When leather is employed, the skins are not tanned, as for boots and shoes, but undergo a lighter dressing. The difference between these modes of preparing leather will be alluded to more particularly hereafter.

When the material of which gloves are made is prepared, it is cut to the proper form, and then sewn up either by hand or machinery; the former is more generally the case, as the latter mode is not cheaper, but tends to greater regularity in the stitches. Cotton gloves are an invention of comparatively recent date, and are rapidly displacing leather gloves in the market. Still, however, leather gloves, particularly kid, will always remain in favour; and the legislative enactments respecting them will show the change which has taken place in our ideas of freedom of commerce. The importation of leather gloves and mitts was, until 1825, prohibited under the severest penalties. This prohibition had the effect, by preventing all competition and emulation with foreigners, of checking improvement, and of rendering British gloves at once inferior in quality and high in price. In that year the prohibition was removed, and foreign gloves were admitted on payment of a duty of four shillings per dozen pairs. This duty was certainly high; but it did not prevent the English glovers from raising a great outcry respecting the ruin of their trade, which was now said to be certain. But the effect which had been foreseen by the legislature speedily showed itself. The English manufacturers, in order to cope with their foreign competitors in the market, set about improving the manufacture in every possible way. The consequence was, according to Mr. McCulloch, that though from one to two hundred thousand

dozen pairs of foreign leather gloves have been imported of late years, yet the English leather gloves have not decreased in quantity, while English cotton gloves have prodigiously increased. The effect of all this is, that persons, who used to consider gloves a luxury, can now afford to purchase them, on account of the reduction in price. A similarly happy result generally attends the breaking down of restrictions to commerce between different nations.

Glove-making is carried on chiefly in and around the city of Worcester. There are a great many manufacturing firms in that city, who purchase prepared leather, chiefly from Bermondsey, and cause it to be cut up into pieces of the proper size and shape for gloves. The female cottagers, and the wives and daughters of labouring men, residing within eight or ten miles of Worcester on every side, come for these pieces, take them to their humble abodes, sew them up into gloves, and convey them back to the warehouses at Worcester, where they receive payment. Sometimes the manufacturer sends an agent to meet the glove-makers nearer to their own homes.

The leather gloves made in England amount to about half a million dozen pairs every year; but the amount of cotton gloves has not been exactly determined.

Chapter VII.

HATS.

The Felting Property of Wool.

From the *hands* and *feet*, we shall transfer our attention to the *head*. The very great similarity between the shape, colour, and materials, of the hats worn by nearly all classes in England, renders this kind of head covering more easy of general description than other and more diversified articles of dress.

A beaver or silk hat is in many respects remarkable. The sombre head-covering which a black hat constitutes, and the total absence of every kind of ornament from it, furnishes a striking contrast to the head-coverings of most nations. But it is in the peculiar formation of the material whence hats are made that they are chiefly remarkable: this formation is called *felting*, or *felted wool*.

Respecting the origin of *felt*, little is known. It is said that a monk, having used some carded wool instead of socks, found that the fibres, by long friction between the foot and the shoe, had become matted together so as to produce a firm texture something like cloth, and from this hint arose the manufacture. But a better explanation may perhaps be given. It has been judiciously observed, that the Asiatic shepherds who sewed together the skins of animals to make themselves garments, could scarcely have avoided detecting the felting property of furry, hairy, or woolly fibres. The probable steps have been thus conjectured:—The tendency of matting, or felting, or entwining on certain parts of the living animals would be first taken notice of; and when these portions were separated from the fleece, curiosity or accident would discover that this process might be extended to a greater or less degree by beating, or by pressure, and that the wool would form a soft, and pliable, and warm substance, evidently fitted for human clothing; and far more comfortable, and more easily applicable to the wants of the individual and of society, than the skins that had been previously used. The felting property of wool would thus be developed; and that rude species of manufacture, by means of which the fleece used to be converted into cloth, would thus be invented and gradually improved.

The reader will remember that in page 64 we described the process by which woollen cloth, after being woven has its fibres worked or bristled up, and then entangled among one another so as to form what we call the *nap* of cloth: the process is called *fulling* or *milling*, and bears a similarity, in some respects, to felting. *Felt* may be called a cloth made without weaving. As the entangling property of woolly fibres is the groundwork of a felted material, we must here speak somewhat more fully concerning it.

If we hold a human hair firmly by the root, and draw it gently between the finger and thumb, it passes through smoothly, and with hardly any sensible resistance or interruption; whereas, if we reverse the motion by holding the hair by the point, and draw it from point to root, a very sensible tremulous resistance will be experienced, accompanied by a creaking kind of sound. Again, if we place a hair loose between the finger and thumb, and then, by alternately bending and extending them, give them a backward and forward movement, the hair will be put in motion; and this motion will always be from root to point, whether the root be in one or the other position with respect to the rubbing surfaces. A fibre of wool, likewise, in similar circumstances, always moves in one direction. Every schoolboy knows, that an ear of barley, if put within the sleeve at the wrist, soon travels up to the armpit; and that he can only rub a single awn of barley in *one* direction between his finger and thumb, viz., from root to point. The awn of barley is visibly jagged at the edge like a saw, the teeth pointing obliquely upwards, and this particular conformation is manifestly the reason why it is capable of motion in one direction but not in the other. These facts led to the discovery of the cause of felting.

Those who have opportunities of examining a lock of wool, observe that it presents a much more crisped and spirally curled form than hair. This can be seen by holding a small lock of wool up to the light, when every fibre will be seen twisted into a ringlet or cork-screw form, especially when taken from the fleece of a short-woolled sheep. The goat, the Devonshire breed of cattle, some varieties of Highland cattle, the *yak* of Tartary, and the ox of Hudson's Bay, all present, in certain parts of their coat, a hairy or woolly fibre which possesses this curly form. Different kinds of sheep afford wool having a different degree of curvature or flexure in the curls; and it has been long known that the fibres which curl most are best calculated for the felting process. The curl materially contributes to that disposition in the fibres which enables them

to attach and entwine themselves together: it multiplies the opportunities for this interlacing, and increases the difficulty of unravelling the felt. Still, however, it has long been known, that although this curling assists very effectually in producing the effect of felting, it is not the principal agent concerned: it merely affords the fairest opportunity for the exertion of a property due to some other source.

Some writers on Natural Philosophy formerly thought that felting was due to a kind of attraction of cohesion between the fibres; that, as two very clean surfaces of lead will cohere strongly when pressed together, by virtue of the attraction of cohesion, so do the fibres of felt by an analogous power. Dr. Young says:—"The reason of the contraction of cloth in felting is probably this, that all the fibres are bent by the operation of the fulling-hammers, but not equally, and those that have been the most bent are prevented by their *adhesion* to the neighbouring fibres, from returning to their original length." There is this defect in Dr. Young's explanation, that whether it be correct or not in reference to the "fulling" of cloth, where the fibres are beaten for hours by heavy hammers, it does not apply to hat-making where the fibres are rubbed and not beaten.

When the idea was afterwards started that the friction of hairs, ears of barley, &c., might solve the difficulty, many fanciful theories were built up. Mr. Bakewell imagined that the roughness or tremulous motion "might be caused by minute vibrations, more easily excited in one direction than another, owing to the peculiar arrangement of the particles, or of the small filaments which compose the substances of wool or hair." This opinion, however, is altogether untenable.

Monge, the celebrated French philosopher, was the first who satisfactorily explained the process of felting; but a letter written previously by Mr. Plint to Mr. Youatt, gave some very happy conjectures in the matter:—

"Respecting the application of the microscope to the examination of the fibre, I am decidedly of opinion that a careful and minute examination of wools differing in their felting properties would issue in the detection of some specific difference of structure. This property is altogether inexplicable, at least in my mind, except in the supposition that the extreme surface of the fibre is irregularly feathered, and that, by compression, these feathered edges become entangled and locked together. These feathers must also point in one direction, viz., from the root to the

plies to all of these), renders the explanation of the process of felting comparatively easy. When wool or fur is wrapt in a damp cloth, and pressed and rubbed in every direction, the action brings the filaments closely in contact, and multiplies their touching points. The agitation gives to each hair a progressive motion towards the root: but the roots are disposed in different directions; and the lamellæ of one hair will fix themselves on those of another hair which happens to be directed in a contrary way. The hairs thus become linked or twisted together, and the mass assumes a compact form.

Beaver-Hat making.

This, then, being the principle on which filaments of wool tend to mat or felt together, we will proceed to show how this tendency is taken advantage of in the manufacture of a beaver-hat. We will select, as an example, the common mode of making a good beaver-hat, of which the body or foundation is felted wool, and the nap or covering is the fur of the beaver, mixed with a little of that of the hare, or of some other animals.

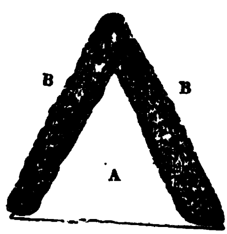
The wool, generally of the sheep or lamb, is shorn from the living animal; but the fur is taken from the skins, by first drawing out by the roots, by means of a blunt knife, the long and coarse hairs, which are rejected, and afterwards shaving off, with a very sharp knife, the down or finer hair for use.

The wool (which varies in kind and quality according to circumstances) is washed, scoured, dried, and carded, before it comes into the hands of the hat-maker. His first employment is to *bow* the wool, an operation by which all the filaments are separated from one another, and rendered as light and downy as possible. The wool is generally mixed, for the foundation of hats, with a coarse inferior kind of fur, and these are *bowed* separately. The fur being thrown down in a heap, the workman employs a bow (made somewhat like a violin bow, but with only one string) above six feet in length, and in order to render it more manageable it is suspended by a strong cord. This bow being brought over the heap of fur, the workman gives a strong vibration to the string by striking it with his thumb or with a knobbed stick, the effect of which is to put in motion and completely separate from each other all the hairs that it touches: this is continued till all the lumps and clots are broken down so as to leave the hairs separated and lying as lightly over

one another as possible. A light wicker frame, like a common fire-guard, is then employed to sweep the hair a little on one side, in order to make way for the wool, which is bowed in the same manner as the fur, but with a larger bow and a stronger string. The fur and wool are then laid one on the other, pressed with the wicker frame, and again bowed till a complete and equal mixture of the two materials has been brought about, and an equal distribution has been made over the space that they occupy.

The wool and fur then undergo the process of *hardening*. The heap is brought to a tolerably even surface, and is covered with a piece of oil-cloth. Pressure, at first very gentle, and increasing by degrees, is made on the oil-cloth by the hand of the workman, till, in a short time, the fibres have become intermixed, forming a layer which will just bear careful handling. The oil-cloth being removed, a piece of damp brown paper, shaped like an equilateral triangle, is put on the layer, the edges being folded over so as to cover and enclose the paper, except at one edge. In this state it is folded up in a damp cloth, and worked by hand, pressing and bending it, rolling and unrolling it, so as to give every fibre an opportunity of intertwining more or less with those in its neighbourhood, and thus of forming a thin though imperfect and loose felt. The paper being now taken out, the felt may be opened into a sort of conical cap, for the paper has prevented the opposite surfaces of it from felting together. This process is called *basoning*.

Sometimes the conical cap is prepared in two pieces, as follows. The wool is suffered to come only a small dis-



tance over the paper, leaving a paper surface A surrounded with a woolly border B. Another triangular piece of wool is then prepared, and on it the first-made portion is laid, paper downwards, so as to unite by its edges with the tri-

angular piece beneath. The two are then made thoroughly to unite together, and the paper is drawn out from between them.

The conical cap is now ready for *planking*. A boiler, called the "kettle," is placed in the middle of the room, with seven or eight inclined faces, or planks branching out from it; each of which affords room for one workman. The boiler contains a liquid composed of several substances, such as water, sulphuric acid, wine-lees, and beer-grounds, combined in different proportions. The liquid is just below the boiling-point when used. A workman takes one of the felted *bodies*, as they are now called, lays it on one of the planks, and sprinkles it with the hot liquid; he then rolls it and unrolls it, pressing it with a piece of leather tied to his hand; during the whole of which operation it shrinks and becomes proportionally thicker and more compact. It is next dipped for a few seconds into the boiling liquor, and is then rolled and worked on the plank as before, the result of which is, a still farther contraction and thickening of its substance. Lastly, the scalding is repeated, and the felt is worked and squeezed by means of a rolling-pin, called a *walk-pin*, till it ceases to contract any farther. Thus the act of felting, which was begun by the *basoning*, is finished by the *planking*; and consists of rolling and pressing, first very gently and at the common temperature, then with a greater force, assisted by the action of warm acid liquor, and finally with the greatest force that the workman can apply, and at a scalding temperature. The effect of the acid is probably to facilitate the solution or removal of any oil or mucus which may be squeezed out from the hairs, which, if allowed to remain among them during their working, would impede their tendency to dry. The felted substance is now laid aside to dry.

The next process is to put in the *stiffening*, which is a saturated solution of shell-lac in alcohol, mixed with some other substances. This is applied by means of a brush to the inner surface of the felt, and sometimes to the outer likewise; after which it is again dried in a stove; by this process the felt is impregnated with a resinous substance capable of giving the required stiffness to it, and also of rendering it to a considerable degree impenetrable by rain or cold water. In the act of drying, some of the lac is generally brought to the surface, making it rough; this is removed by dipping the felt in a hot solution of alkali, which loosens the crust of lac, and allows it to be scraped off. The felt is then a third time heated in a stove, and when nearly dry is singed by holding it over a blaze of

shavings, in order to remove the hairs which stand out from the surface of the felt.

The next process is one of considerable nicety, viz., the putting on of the nap, or *roughing*, as it is called, which constitutes the external surface of the finished hat. To form the nap, from half to three quarters of an ounce of beaver fur, together with a small quantity of some cheaper fur, and a little fine cotton, are carefully *bowed*, and then by means of the oil-skin, are made into a very tender imperfect felt of the shape of the body intended to receive it, but about three inches longer: a strip three inches wide, therefore, being torn off from the bottom of it, the remainder is just sufficient to cover the body, while the strip is reserved for the under part of the brim of the hat. The nap being thus prepared, the body is softened by dipping it in the boiler, and is then covered with the nap, the strip being applied on the lower part of the inside. It is then taken to the plank, and the nap is fixed to the body, by first patting it down with a wet brush, then rolling it in a hair-cloth, dipping it in the hot liquor, and working it about as in the process of felting.

The manner in which the beaver adheres to the felt is very curious. When first laid on, the beaver hairs form a horizontal layer, the individual hairs lying in all directions. As soon as the rolling and pressing begins, each hair is put in motion from root to point, and enters the substance of the felt body. These hairs have considerable stiffness and elasticity, and proceed, therefore, in a pretty straight course through the felt, with the substance of which they form a union; but by a sufficiently long continuance of rolling and pressing, they would actually pass through the felt and be seen on the inside instead of the outside. When the process has been continued just long enough, the hairs will have penetrated by their root sufficiently far to secure them from being drawn out in brushing the hat.

The reader must bear in mind, that throughout these processes the hat-body has no other shape than that of a cone, pointed at one end. The period has now arrived when it is to receive the form of a hat, by a process which is perhaps the most remarkable in the whole manufacture, and which is called *blocking*. The workman turns up the edge or rim of the cone to the depth of about an inch and a half, and then returns the point of the cone back again through the axis of the cap, so as produce another inner fold of the same breadth. A third fold is produced by returning the point of the cone again, and so on, till the whole resembles a flat circular piece, having a number of

moisture and heated irons, the frilled brim is shrunk until reduced quite level, the nap gently raised all over by a fine wire brush, and brushed and ironed smooth in a uniform direction. The hat is then strengthened by inserting a lining in it; and it is *finished off* by bending the brim into the required form, trimming, &c.

Attempts have been made, and probably will fully succeed hereafter, to prepare the felt for hats by machinery, instead of working and moulding it by hand. Many patents have been taken out, having this object in view; and the general mode of accomplishing it is by coiling loose filaments of wool into the form of conical caps, and causing them to cross each other in the winding on, for the purpose of taking hold of each other, so as to produce a matted texture when exposed to heat and friction. The machine for effecting this is generally attached to a carding engine, by means of which the *slivers*, or porous ribbons of wool, are taken off the carding engine, and wound in different directions, for the purpose of becoming matted together upon blocks of various figures, suited to the size of the intended hat. A conical roller presses down the woolly filaments, as they are wound round the block, by which they are made partially to felt among one another. The cap is then removed from the block, folded in a wet cloth, and placed on a steam-heated plate, where it is rolled by a machine, for the purpose of becoming condensed. It is now to be felted, either in the usual way by hand, or in a fulling-mill, from which it is taken out occasionally and passed between rollers, to render the felt more perfect.

Silk Hats.

We have thus given a succinct detail of the processes connected with the manufacture of a beaver hat. But partly on account of the rise in the price of beaver fur, and partly from the general desire for *cheapness* which has so much shown itself of late, many substitutes have been invented of late years. It will be desirable to state the distinctions which the maker observes between different kinds of hats.

Hats are called either *felted* or *covered*, and there are different kinds of each. Of felted hats, *wool hats* are made entirely of coarse native wool and hair stiffened with glue, and are of a very inferior kind: *plates* have a nap or pile rather finer than the body of which they are made, and

are sometimes *waterproof* stiffened: *short naps* are distinguished from *plates* by additional kinds of fur, such as hare's back, seal, neutria, mushquash, &c., and are all *waterproof* stiffened: *mottled bodies* are made chiefly of fine Spanish wool and inferior rabbit down: *stuff bodies* consist of the best hair, Saxony and red wools, mixed with Cashmere, hair, and silk: *stuff hats* are *napped*, that is, covered with a pile of mixed seal, neutria, hare-back, inferior beaver, and musquash: *beaver hats* are napped with beaver only, the inferior qualities with the fur taken from the back of the animal, and the superior with that from the belly and cheeks.

Covered hats consist of a foundation or *body* made of cambric, woollen cloth, stuff, or plaits of willow, straw, or leghorn, covered with silk, or sometimes with Angola cotton.

Covered hats are manufactured in the following manner. A foundation or body is made of willow, or some one of the substances before mentioned, and on this is fixed a silk *bag* or covering, which exactly encloses it in every part, and constitutes the silken surface with which we are so familiar. This silk bag is formed of *plush*, or a kind of velvety silk fabric with a long nap or pile. This is manufactured for the purpose, and is stitched up into the proper size before it is laid over the foundation. Heat and moisture with different liquids, are used in the act of causing the silk covering to adhere to the foundation. The source of this difference between the modes of making beaver and silk hats is, that silk does not possess the peculiar property of *felting*.

Straw Hats.

Here we have another instance of the tendency which has been shown to the production of garments by an interlacing of strips or fibres. The stalks or straw of grain, by being interwoven among each other, form broad strips or bands, and these bands, either by farther interlacing, or by stitching, form that extensive class of head-coverings which we know as *straw hats* or *bonnets*.

Italy was probably the birthplace of straw hats; but England has for a long period produced large numbers of these light and very convenient head-coverings. The *straw-plait district*, as it is familiarly called, comprises the counties of Bedford, Hertford, and Buckingham, being the most favourable for the production of the wheat straw,

which is the material chiefly used in England. The manufacture is also followed at some places in Essex and Suffolk. During the late war, the importation of straw hats from Leghorn having in a great measure ceased, an extraordinary degree of encouragement was given to our domestic manufacture, and a proportional degree of comfort was derived by the agricultural labourers in these counties, by the wives and children of whom it was chiefly followed.

The English mode of plaiting the straw under the system which was followed until recent improvements were introduced, is as follows:—The plaiters select the whitest and most regular straws, and cut them into equal lengths; the straws are then whitened, by inclosing a number of bundles in a large box, leaving a considerable space in the middle, into which a cup filled with sulphur is placed, and this being kindled, the box is shut close, and covered up with a wet blanket, to keep in the vapour of the burning sulphur, which insinuates itself through all the bundles of straw contained in the box, and renders them white, and of a more delicate colour. After this preparation, the straws are split lengthwise into several segments, by means of a wire fitted to the interior cavity, and having four, six, or eight sharp edges projecting radially from it; the straws will easily split in the proper directions when the wire is thrust through them. For the convenience of holding this wire, one end is bent at right angles into a sort of a handle. The slips of straw are now softened in water, and plaited together by children, with great rapidity and exactness. The mode of plaiting can scarcely be described, but most persons have a sufficiently clear idea of the process. The most simple plait is that of three straws; but this is only for very coarse articles, the slips of the straws being very broad. Sometimes whole straws are employed, being first pinched flat by softening them and drawing them between the fingers. After the plait, whatever kind it may be, is finished, it is passed several times between a pair of small wooden rollers, to render it flat and solid. Of these plaits or ribbons the hat is formed, by winding them in a spiral direction, round a proper shaped wooden mould or block, with a little overlap, and sewing them together; and when it is thus finished, the whole is passed over with a hot iron, to smooth down the seams; and the block is then taken to pieces, to withdraw it from the hat.

Such was the usual system of making straw hats in England; but the exclusion of foreign hats during the war, led to many improvements in splitting, finishing, and

bleaching the straws; indeed so far was this successful, that some of the women employed upon the straw-plaiting earned a guinea a week at it. But when the cessation of the war permitted the importation of foreign hats, their superiority in fineness, colour, and durability, speedily regained for them a preference over our home manufacture. The most active exertions were therefore made, to improve as much as possible the English manufacture: not only were improved modes of manufacturing native straws of various kinds adopted, but Leghorn straws were imported, and the Italian mode of plaiting introduced.

The Italian process, according to Mr. Mc Culloch, is the following. The description of straw used, which is cultivated solely for the purpose of the manufacture, and not for the grain, is the *Triticum turgidum*, a variety of bearded wheat, which seems to differ in no respect from the spring wheat which is grown in the Vale of Evesham, and other parts of England. After undergoing a certain preparatory process, the upper parts of the stems (being first sorted as to colour and thickness) are formed into a plait of generally thirteen straws, which is afterwards knitted together at the edges into a circular shape, called a *flat*. The fineness of the flats is determined by the number of rows of plaits which compose them (counting from the bottom of the crown to the edge of the brim), and their relative fineness ranges from about No. 20 to No. 60, being the rows contained in the breadth of the brim, which is about eight inches. They are afterwards assorted into first, second, and third qualities, which are determined by the colour and texture. These qualities are much influenced by the season of the year in which the straw is plaited. Spring is the most favourable, not only for plaiting, but for bleaching and finishing. The dust and perspiration in summer, and the benumbed fingers of the workwomen in winter, when they are compelled to keep within their smoky huts, plaiting the cold and wet straw, are equally injurious to the colour of the hats, which no bleaching can quite remove. The flats, when finished, are made up in cases of ten or twenty dozen, and are ready for exportation.

Mr. Mc Culloch makes the following remarks on the English straw-hat manufacture. "There is, perhaps, no manufacture more deserving of encouragement and sympathy than that of straw plait, as it is quite independent of machinery, and is a domestic and healthful employment, affording subsistence to great numbers of families of agricultural labourers, who without this resource would be reduced to parish relief. By an estimate of an intelligent

individual, intimately acquainted with the manufacture, it is considered that every twenty yards of plait consumes a pound of straw in the state in which it is bought of the farmer; that, at an average, every plaiter makes fifteen yards per day; that in the counties of Hertford, Bedford, and Bucks, there are, at an average, 10,000 score yards brought to market every day, to make which 13,000 persons (women and children) must be employed. In Essex and Suffolk, it is estimated that 2000 scores are the daily produce, to make which about 3000 persons are employed; and about 4000 persons more must be employed to convert these quantities into bonnets. Including other places where the manufacture is carried on in England, there are, perhaps, in all, about 30,000 persons engaged in it. The earnings of the women and children vary from 3*d.* to 3*s.* 6*d.* per score yards, or from 1*s.* 6*d.* to 10*s.* per week. There are seven descriptions of plait in general use, viz.:—*whole Dunstable* (the first introduced), plaited with seven entire straws: *split straw,* introduced about thirty years since: *patent Dunstable,* or *double seven,* formed of fourteen split straws, every two wetted and laid together, invented about twenty-five years since: *Devonshire,* formed of seven split straws, invented about sixteen years since: *Luton plait* (an imitation of whole Dunstable), formed of double-seven, and coarser than patent Dunstable, invented about ten years ago: *Bedford leghorn,* formed of twenty-two or *double eleven* straws, and plaited similarly to the Tuscan; and *Italian,* formed of eleven split straws. But there are other varieties in fancy straw plait, not generally in demand for the home trade, but chiefly required for exportation; such as the *backbone,* of seven straws; the *lustre,* of seventeen straws; the *wave,* of twenty-two straws; and the *diamond,* of twenty-three straws. There were other plaits called *rustic,* of four coarse split straws, and *pearl,* of four small entire straws; but these are now superseded. The principal markets are Luton, Dunstable, and St. Albans, where the plait is usually brought every morning by the plaiters, and bought by the dealers."

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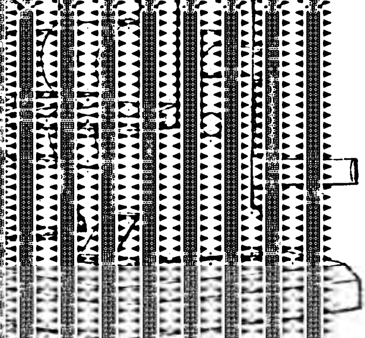

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flat surface, which forms, with the projecting ledge *b*, a narrow crack, so that by pushing the straw along the blade it is split open, and gradually flattened so as to enter this crack, where it is further flattened sufficient to enable the rollers to grasp it, which they do readily when motion is imparted to them by turning the handle G. After passing through the rollers the straw falls down on the other side in an opened and flattened state. By means of this ingenious little machine ten thousand straws can be prepared in one day, whereas by the old method not more than one hundred could be got ready.

In ornamental straw-work, the straw is dyed of various colours. A few simple directions for dyeing the straws in some of the principal colours may be given here.

Blue is obtained from a solution of indigo in sulphuric acid. It is better to purchase a small portion of this solution than to attempt to prepare it. A large pipkin containing water is to be set on the fire, and when the water boils, the indigo solution is to be added a little at a time until the desired shade or colour is produced. The vessel is to be removed from the fire, and the straws immersed; when the colour has struck they are to be taken out, washed in cold water, and dried. For higher shades of blue, hot water is to be added to the last preparation, and the whole boiled. The straws are to be immersed while the solution is boiling. In this way, by various additions of water, a variety of shades of blue may be obtained.

Yellow is produced by a decoction of turmeric diluted to the desired shade, in which the straw is boiled until it has taken the colour. From these dyed straws a large variety of *greens* may be obtained by plunging them into the boiling-hot indigo solutions of various depths of shade, as employed for the production of blue straws.

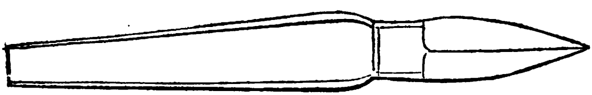
Red.—For the production of various shades of red, the whitest straws must be selected. The dye is produced by boiling hanks of coarse scarlet wool in a weak solution of alum water. The wool soon parts with its colour to the water, and when the desired tint is attained, the whole solution is poured upon the straws contained in a flat earthen vessel, and allowed to remain till cold. When the straws are removed they must not be washed, but allowed to dry spontaneously. Red is also obtained by employing cochineal, salt of tin, and tartar.

By diluting more or less the solution used for the red dye various shades of red, such as flesh-colour, rose-colour, &c., may be obtained; but the straw must be boiled

with the solution. By employing the light blue straw in the last-named solution, *violet* is obtained.

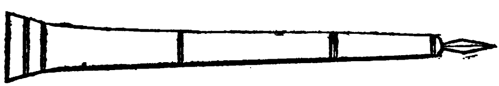
A *black* dye is procured from nut-galls, sulphate of iron, and Brazil-wood.

The processes of dyeing being complete, the straws must be sorted, not only for distinct colours, but for shades of the same colour, because it generally happens that a number of straws dyed in the same solution do not all take the same shade. The rough edges must then be cut smooth, for which purpose they ought to be placed upon a hard even board, and so covered with a thin flat iron ruler that the ragged portion only may project: this is cut off by means of a lancet-shaped knife, of which the form recommended is shown in the figure.



It is recommended to paste the under surface of the straws thus prepared to large sheets of thin paper: each sheet to contain one distinct colour or tint, and when the pasting is completed, to subject the whole to a strong pressure in a press, taking care to interpose between each sheet of straws a few folds of blotting-paper and a stout board of the size of the sheet. After remaining in the press for about twenty-four hours, the sheets may be removed, and preserved for use in a large volume or portfolio.

The tools required for this kind of work are few and simple: 1. A ruler of iron or brass, very smooth, and the edge quite true. 2. A lancet-shaped cutter such as we



have already described; and also a pointed cutting knife, fixed in a somewhat massive wooden handle: the cutting point for trimming up fine and delicate work, and the handle for pressing, polishing, and flattening the work. 3. Two pairs of compasses with openings fixed at about one-tenth and three-tenths of an inch. These are formed of a handle of wood, A, with a groove on each side of the lower part adapted to the reception of a needle: by passing

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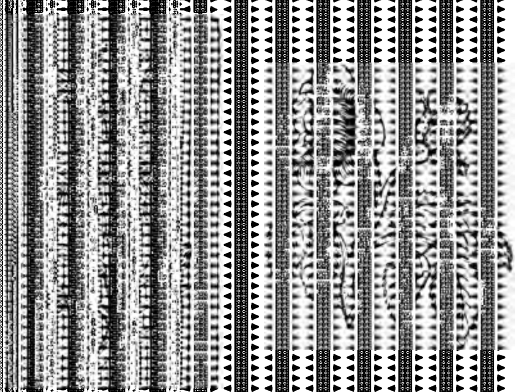

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Chapter VIII.

GARMENTS OF LEATHER.

We have now taken leave of that most important class of clothing materials which consists of fibres either woven or felted into an extended fabric, or cloth. There is not a single part of the human body but what has been covered with one or other of such fabrics, in accordance with some of the ever-varying fashions which govern costume.

There is, however, one part of the body which is exposed to more severe pressure and "wear and tear" than any other, and which requires for its covering and protection a garment of considerable strength—we mean the *sole of the foot.* The thickest woollen, silk, cotton, or linen texture would be worn through if exposed to the nimble activity or persevering toil of the feet for a single day. If these fabrics then, will not suffice, what are we to use instead?—iron, wood, leather? Iron and wood, hard and firm as they may be, are not calculated to yield to the flexure of the foot in walking; and it is consequently found that to walk in wooden shoes is a most fatiguing operation; for when the foot is incased in such an unyielding material the muscles of the leg cannot bring into play its beautiful elasticity, which not only greatly diminishes fatigue in walking, but by affording gentle exercise to all the other parts of the body, contributes to health and cheerfulness. A dancer's leg is fleshy and roundly formed, principally on account of the incessant action to which the foot is subjected in bending: a ploughman's or a wagoner's leg is generally small, not because he has but little walking, for the contrary is the fact, but because his unyielding shoes render it impossible for his foot to bend into those forms which so much assist the act of walking; and this inactivity of the foot leads to a similar inactivity in many of the muscles of the leg which act upon the foot.

Now it happens, fortunately for us, that *leather* is a substance, possessing more toughness and durability than woven fabrics, and more flexibility than wood or iron: there is perhaps scarcely any other substance in nature that possesses so much flexibility with so much toughness. We do not despair of seeing the day when *steel* or *iron,* by the aid of springs or hinges somewhat similar to those

recently employed for ladies' clogs, may be formed into boots and shoes,—more wonderful things than that have been effected by our manufacturers within the last few years. But, until such a time arrives, we must all agree that there is "nothing like leather."

The question, "What is leather?" becomes, therefore, not an unimportant one. We will endeavour to show what leather is, and how it is prepared; and may afterwards briefly treat of the mode of making it into boots and shoes.

Leather consists of the skins of animals, deprived of their putrefactive quality, and rendered tougher and stronger, by the action of a certain chemical substance. When the hair, the thin skin, the fleshy or fatty portions, and other extraneous matters, are scraped from a hide, the remainder consists of a substance called *gelatine*, which is partially soluble in water: the particular chemical substance to which we have alluded, and which is called *tannin*, is also soluble in water; and this tannin, if left for a length of time in contact with the gelatine, will convert it into leather,—or rather, the union of the two together forms leather.

Tannin is a vegetable principle, and has been found most abundantly in the *barks* of various trees, *Aleppo galls*, and *caoutchouc*, &c. Sir Humphry Davy undertook a long course of experimental inquiry to determine which body contained the largest quantity of that valuable material. Tanners in England had for a long time employed oak-bark for tanning, without any very distinct idea of its action. Foreign tanners had been using galls, and several other substances; and when oak-bark became very dear in England, it was thought necessary that an investigation should be made, to discover whether some common property or principle was resident in all these bodies. This was done, and it was found that all of them contained a peculiar substance, which, from its valuable property of tanning leather, obtained the name of *tannin*. Sir H. Davy afterwards found, that, for the purposes of the tanner, $8\frac{1}{2}$ lbs. of oak-bark are equal to $2\frac{1}{4}$ of galls., 3 of sumach, $7\frac{1}{2}$ of willow-bark, 11 of chestnut-bark, and 18 of elm-bark.

To obtain oak-bark for the tanner's use, it is ground to a coarse powder between cast-iron cylinders, and in that state is put into the tan-pit. An infusion of the bark in water is also employed.

Galls, which contain a large portion of tannin, are the result of a kind of disease to which oak-trees are subject, in consequence of the attacks of a peculiar insect which

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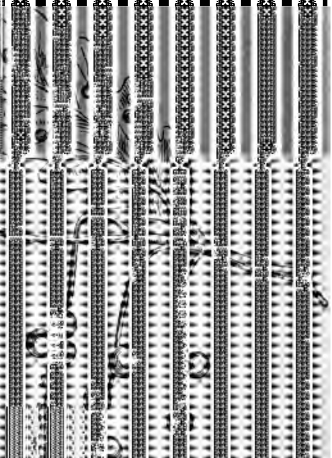

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verted into dry cakes, which so much resemble earth that they used to be called *terra Japonica*. These cakes are easily soluble, and are particularly rich in tannin.

Such, then, are the substances containing the tannin which will convert animal hides into insoluble and imputrescent leather. Oak-bark is, for many reasons, the tanning substance usually employed in England.

The process of tanning is one of the slowest in the whole circle of our manufactures. Many months are consumed in thoroughly impregnating the hides with the tannin by the usual method: and it is not surprising that repeated attempts should have been made to improve and accelerate the process. We believe, however, that none of them have fully succeeded, probably from a want of knowledge of some of the circumstances connected with the chemical formation of leather. We may reasonably expect that some of the new methods will be ultimately successful; but, as most tanners still follow the old routine, we will confine ourselves to a brief description of *one* of the long-established methods; for most tanners make slight changes in some part or other of the process. The reader will therefore take the following as a general account of the whole.

We may here state, that the skins of the larger animals, such as the ox, &c., which are devoted to purposes of strength, are called *hides*; while the thinner ones, such as those of the calf and sheep, are called *skins*. Hides are also divided into different qualities or thicknesses, by the names of *butts* or *bucks*, and *crop-hides*, the former being the thickest kind of leather ever produced.

Tanning Butts.

The stout bull and ox hides, called *butts*, are tanned in the following manner. After the horns, &c., have been removed, the raw hides are laid in a heap for two or three days, and are then suspended on poles in a close room called a *smoke-house*, which is heated somewhat above the common temperature by a smothering fire: this occasions incipient putrefaction, which loosens the epidermis, or thin skin of the hide, and renders the hair and other extraneous matter easy of separation from the true skin. This separation is then effected by extending the hide on a wooden horse or beam of a convex form, and scraping it with a large two-handled knife, called a *fleshing-knife*, which is bent to suit the convexity of the beam.

The hides are then immersed in a pit containing water slightly impregnated with sulphuric acid. This operation, which is called *raising*, by distending the pores and swelling the fibres, prepares the hide for the reception of the *tannin*, and renders it more susceptible of chemical action.

When the hides are sufficiently *raised*, they are removed into a pit, in which they are laid out smooth, with a stratum of coarsely-pounded oak-bark between every two hides. The pit is then filled with a tanning liquid, or *ooze*, as it is called, which is prepared from oak-bark and water; and the hides remain a month or six weeks without being moved. At the expiration of this time the tanning principle being exhausted, the ooze and spent bark are taken out of the pit, and the hides again put in, stratified with fresh bark, and covered with fresh ooze, as before. Here they remain about three months, when the same process is repeated, the bark and ooze being removed two or three times in the interval. When the hides are sufficiently tanned, they are taken out of the pit, hung up in a shed to dry gradually, and, being compressed with a steel instrument, and beaten smooth, to render them firm and dense, the operation is complete; and having been numbered, weighed, and stamped by the Excise officer, in order to fix the duty payable on them, they are ready for sale as *butts* or *bucks*. These form the soles for shoes of the greatest stoutness.

Tanning Crop-Hides.

The thickness of hide employed for the soles of shoes in general is not required to be so great as that just alluded to: a thinner sort, therefore, called *crop-hides*, are used for this purpose; and the mode by which they are tanned differs in some degree from the details just given.

After the horns are removed, the hides are immersed in pits containing a mixture of lime and water, where they remain three or four days, being occasionally moved up and down, so that each part may be uniformly exposed to the action of the lime-water. They are then removed from the lime-pit, and after the hair and other extraneous matters have been scraped off in the manner before described, the hides are washed in water, to free them from the adhering lime, &c. They are now immersed in a weak ooze, and by degrees are removed into other pits containing solutions gradually increasing in strength; during which time they are taken out, refolded, and put in again once every day, in order that all parts of the hide may be

acted on equally and uniformly by the tanning principle. This is continued for a month or six weeks; after which they are put into other pits with stronger ooze and a small portion of ground bark; whence, as the tannin becomes exhausted, they are removed to others in regular succession, with fresh ooze and fresh bark, for two or three months.

At the end of this period the hides are put into larger vats, called *layers*, in which they are laid with an ooze of greater strength, with a layer of ground bark between them. Here they remain about six weeks, at the expiration of which time they are taken up, and then relaid with stronger ooze and fresh bark for two months. This process is repeated, with little variation, one, two, or three times, according to the discretion of the tanner, till the hides are thoroughly tanned; after which they are taken out of the pits, suspended on poles to dry, and, being compressed and smoothed, nearly in the same manner as *butts*, assume the form which is called *crop-hides*.

Tanning Calves' and Seals' Skins.

The upper leathers of boots and shoes are generally made of such material as calves' or seals' skins, occupying a medium place between ox and lambs' skins in point of thickness, &c. The calves' skins are laid in lime-pits for ten or fifteen days; they are then scraped and washed in water, after which they are immersed in an alkaline infusion. Here they remain for a week or ten days, according to the state of the atmosphere and other circumstances, during which time they are frequently taken in and out, and scraped on both sides upon a convex wooden beam. This scraping, with the action of the alkali, helps to discharge all the lime, oil, and saponareous matter; renders the skin soft and pliant, and fits it to imbibe the tanning principle. They are now removed into pits containing a weak solution of bark, where they are treated nearly the same as crop-hides, but without having bark stratified between them; the time for remaining in the pit is from two to four months, according to their nature and substance. The skins are then dried, and sold to the currier.

Currying.

This process commences by softening the hides or skins as they come from the tan-pit, in water: they are then placed on a polished beam with the flesh side outwards, and pared with a broad sharp knife, till all the inequalities are removed, and it is reduced to the required thinness. They are then again rubbed and washed with a polished stone, and, while still wet, are smeared with currier's oil (generally fish oil, or a mixture of this with tallow), which renders them much more impervious to moisture, and fit to protect the feet against the inclemency of the weather. They are afterwards hung up to dry, by which the moisture is evaporated, but the oil, which cannot be dissipated by mere exposure, gradually takes the place of the moisture, and penetrates deeply into the pores of the leather. It is then dried either in the sun or in a stoved room.

Blackening the leather is also done by the currier. He rubs the leather, on the grain side, with a liquid prepared from iron, and on the flesh side, with a mixture of lamp-black and oil.

Lambs' Skins.

The processes employed in tanning the thicker kinds of hide or skin do not apply to the thinner kinds. The modes of preparing these vary greatly, according to circumstances: some are not, properly speaking, tanned at all, while others are but partially tanned.

Lambs' skins are prepared by first soaking them in water to remove any loose dirt, &c., and then placing them upon a beam composed of a half cylinder of wood covered with strong leather, and scraping them on the flesh side with a blunt semi-circular knife. They are then hung up in considerable numbers in a small close room heated by flues, where they remain to putrefy. After a time a thick slime works up to the surface of the skin, by which the wool is so loosened as to come readily off with a slight pull. Each skin is then returned to the beam, the wool taken off and preserved, and all the slime worked off with a knife. The skin is then put into a pit filled with lime-water, and kept there from two to six weeks, the time depending upon the nature of the skin: this has the effect of checking the further putrefaction, and produces a very remarkable harden-

ing and thickening of its substance. The skin is again well worked upon the beam, and much of its substance pared down, and all inequalities smoothed with the knife. The skin is then again softened by being thrown into a vat of bran and water, and kept there for some weeks in a state of gentle fermentation, being occasionally returned to the beam. All the thickening produced by the lime is thus removed, and the skin is now as highly purified as possible, and becomes a thin extensible white membrane, called in this state the *pelt*.

Kid and *goat* skins are prepared nearly in the same manner.

The skins are now ready for the process of *tawing* (which is sometimes, but not always performed), and which is effected as follows:—The skins are put into a solution of alum and salt, to which, in some cases, flour and white of egg are added. The skins and the solution are agitated together in a rotatory machine for a few minutes, till the skins have absorbed a sufficient quantity; a process which again gives them a certain degree of thickness and toughness. The skins are then taken out and washed in water, and then again put into a vat of bran and water, and allowed to ferment for a time, till much of the alum and salt is got out, and the unusual thickness produced by it is for the most part reduced. They are then taken to a lofty room with a stove in the middle, and stretched on hooks, and kept there till fully dry, when they become tough and flexible; but to give them a glossy finish, and to take off the harshness to the touch which still remains, they are again soaked in water to extract more of the salt, and put into a large pail containing the yolks of eggs, beaten up with water. After this, the leather being dried, is made pliable and glossy by *staking*, that is, drawing it forcibly to and fro on the edge of an iron plate fixed upright in a bench, until by this means the harsh and rough skin acquires the well-known and beautiful texture of *kid*.

Tawing is the operation which makes the chief difference between the smooth and glossy leather, and the same thin leather with the downy or unglossy surface which we recognise in *wash-leather*.

Morocco Leather.

This beautiful material was originally manufactured, as its name imports, in Morocco; but it is now made in England, by the following process:

The goat-skins (or sheep-skins for "imitation" morocco) are cleansed in lime-water, as before described, and the thickening which they receive is afterwards reduced by soaking them in a particular liquid, by which they are brought to the state of a fine white pelt. If this pelt is to be dyed red, it is sewed up very tightly in the form of a sack, with the grain-side outwards, the dye being required only on this side, and is immersed in a cochineal bath of a warmth just equal to that which the hand will bear, and is worked about until it is uniformly dyed, a process that demands much skill and experience. The sack is then put into a large vat, containing *sumach* infused in warm water, and kept for some hours until sufficiently tanned. The skins intended to be *black* are merely sumached, without any previous dyeing.

After some further preparation, the colour of the fine red skins being finished with a weak bath of saffron, the skins, when dried, are grained and polished in the following manner. They are stretched very tight upon a smooth inclined board, and rubbed over with a little oil, to render them supple. Those intended for black leather, are previously rubbed over with a solution of iron, by means of a stiff brush, which uniting with the gallic acid of the sumach, instantly strikes a deep and uniform black.

They are then rubbed by hand with a ball of glass cut into a polygonal or many-sided figure, which polishes them and makes them very firm and compact. Lastly, the graining, or ribbed surface, by which this kind of leather is distinguished, is given by rubbing the leather very strongly with a ball of box-wood, round the centre of which a number of small equidistant parallel grooves are cut, forming an equal number of narrow ridges, the friction of which gives the leather the desired inequality of surface.

Boot and Shoe making.

Where the greater part of such a remarkably curved surface as the foot is to be covered, it is obvious that *one* piece of leather cannot be made to assume the required form: it must therefore be effected by having two or more pieces of definite sizes and shapes, and fastening them together by some secure and efficient mode. It is also evident that the sides and front of the foot do not require a covering of such thickness and strength as the sole of the foot.

Here then begins the tact and judgment of the shoemaker. He has to select such kinds of leather as will suit the different parts of the foot, and has to cut them into the necessary forms. The way in which the requisite shape of the pieces of leather is to be determined is, by having a model more or less resembling the foot for which the shoe is to be made, and to fit the leather to the surface of this model; by which it can be seen what are the necessary forms and dimensions of the pieces of leather. By a few trials on a common shoe-*last* (as the model is called), it is easy to see what must be the forms of three pieces of leather which will cover the front, sides, and back, of the last, so as to form what is called the *upper leather*.

But the manufacturer has no need to do this for every separate shoe. By long practice, and by the aid of a few standard measures, he knows precisely the form and dimensions of the various parts of a shoe or boot, and cuts them out accordingly. Leather of a medium thickness is cut out to form the quarters and vamps (which together constitute the upper leather): a thicker quality of leather is then cut out to the shape of the sole; an additional piece or two for the heel; and thinner leather for the inside of the shoe.

Let us then suppose that all the pieces are cut out to their proper forms, and that they are handed to the workman to be put together. The first operation is to stitch together the three pieces of leather which form the upper leather. The pieces of leather are held firmly between a long kind of wooden vice called *clams*, and stitched or sewn together: so that three seams serve to give the outline of the upper leather. In the shoe districts of Lancashire, this work is usually done by females.

If the shoe is to be lined, that operation is now done. The thin leather for this purpose, having been previously cut to the required form, is sewn or stitched to the thicker leather already put together. After the seams have been rubbed down and smoothed, the *upper*, as it is now called, passes from the hands of the *shoe-closer*, who has been engaged on it thus far, into those of the *shoe-man*, who fixes the *upper* to the sole. It has been stated by a practical writer, Mr. Devlin, that a Northamptonshire shoe-closer frequently receives no more than a *halfpenny* for closing a pair of shoes, the price varying, at different times and under different circumstances, from that miserable pittance to eleven-pence.

The *shoe-man* begins his office of uniting the *upper* with the *sole* by fixing the inner sole temporarily on the last.

The leather is first wetted and softened, by which it can be worked and hammered so as to fall into the peculiar form of the sole of the last. The upper leather is then put on the last, and gradually drawn down so as to fit properly on the upper part of the last. The *upper* and the *inner* sole are now sewn or stitched together at the edges, as well as a small strip of leather called the *welt*, which is a strengthening piece between the inner and under soles. After this is done, the proper or true sole is fitted on, and hammered into its proper form, and then stitched to the welt.

The shoe is then to be provided with a heel. If the heel be not high, it is merely a piece of leather stitched down upon the sole; but if the heel be high, there is an intermediate piece of leather called a *lift*, and even two such lifts are sometimes used. The main parts of the shoe are now put together, and the edge, &c., being trimmed, blacked, and otherwise improved in appearance, the shoe is finished.—This portion of the work to a pair of shoes is said to cost from 6½*d*. to 5*s*. per pair.

When we here use the word *shoe*, we allude to a common man's shoe. Women's shoes require a somewhat different and more delicate kind of workmanship, especially those made of costly materials; but into such details we need not enter here. We will merely remark, that *double-soled* shoes are those which have *welts;* and that those called *single-soled*, as well as those thin men's shoes called *pumps*, have no welts.

The manufacture of a pair of boots requires stronger workmanship than that of a pair of shoes, and is generally the production of a better workman. The upper leather consists of two pieces, which are joined together by two seams up the sides. The cutting-out of these two pieces requires considerable care, so that their forms may adapt themselves to the shape of the foot. The workman first pastes and sews the linings to the two halves of the boot, to give them that degree of stiffness which is necessary. The seams are then stitched, or *closed* as it is termed, inside out, so that the stitches may not be seen when the boot is finished.

After some farther processes, the leg of the boot passes from the hands of the *boot-closer* to the *boot-maker*, whose business it is to fix the leg of the boot to the sole, and then to affix the heel. This is done by sewing and stitching, much in the same way as in the preparation of a shoe, but additional strength is required, to correspond with the greater stoutness and dimensions of the leather.

The varieties of boot, such as the Wellington, Blucher, Hessian, &c., require different degrees of skill in the workmen, and different processes in some parts; but the consideration of these forms no part of our subject. Boots and shoes made of cloth, jean, and other woven materials, and shoes made with cork soles instead of leather, are among the varieties of the manufacture; but these call for no particular description here.

Shoes made by Machinery.

During the long wars which desolated Europe for so many years, and which terminated in 1815, a vast number of shoes were required for the British infantry; and the ingenious engineer, Mr. Brunel, devised a system of machines by which these could be made without any *sewing* or stitching to connect the upper with the under leather. He established a manufactory at Battersea, chiefly with a view of supplying the army, and his machines were so complete, that the invalid soldiers at Chelsea who were unfit for any other employment, were capable of superintending them, and the various processes of shoe-making.

We may, however, previously remark, that an American, Mr. Randolph, had invented a mode of fixing the under to the upper-leather by *rivets* instead of *sewing:* but this was all done by hand. A *last* was employed, made of wood, with a steel sole or bottom. The upper-leather having been sewn in the usual manner, and the thin *inner* sole, together with the true sole, cut to the proper size, the riveting was thus effected:—The inner sole was put upon the iron sole of the last, then the upper leathers were fitted round the sides of the last, and the edges turned down over the inner sole. The outer or true sole was then applied over the turning-down, and fastened in a temporary manner upon the last. Then, to unite the two soles to the upper leather, holes were pierced all round the edges of the sole, and small nails driven in, which were of sufficient length to penetrate through the sole and the turning-in of the upper leathers, and also through the inner sole, so as to reach the metal face of the last, and being forcibly driven, their points were turned by the steel, so as to clench withinside. Thus these rivets served the place of stitching.

Now Mr. Brunel's invention was a similar application of rivets, but with the notable addition of doing nearly the whole by machinery: thus affording an example of the varied talents of a man who could construct the greatest works in civil engineering, or *descend,* as some would erroneously term it, to make a pair of shoes.

The various parts which constitute the shoe as made by this machine are as follows:—The upper leather, consisting of three pieces, the *vamp*, forming the covering for the front of the foot, and the two *quarters*, which surround the heel;—the *inner* or *upper sole*, on which the foot rests;—the *lower* or *true sole*, which treads on the ground;—the *welt*, a narrow slip of leather between the two soles;—the *heel*, fixed to the true sole; *short nails*, of a length to penetrate only through the lower or true sole;—*tacking nails*, long enough to go through both sole and welt;—and *long nails*, which penetrate through lower sole, welt, upper leather, and inner sole, and fix all together.

These several parts are shaped and fixed with great ingenuity. In the first place the leather is cut out. Sharp stamps are formed, of shapes suited to the vamps, quarters, welts, soles, and heels. The hide or skin of leather is laid down flat on a table, and the proper stamp being laid upon it, a blow with a heavy mallet, or a pressure by the arm of a lever, cuts out the leather to the proper shape. The three pieces forming the upper leather are then stitched together by hand, it not having yet been found practicable to fasten such thin leather by means of rivets.

The *welts* of all shoes diminish in thickness from the outer to the inner edge: they form in fact, merely a substance to fasten the sole to, in order to increase its thickness near the edge of the shoe. In the machine-made shoes, the welts are made to diminish in thickness by a cutting-machine, by which two welts are made of one strip of leather. The leather is first cut into strips about an inch in width; and these strips are guided between two rollers to a cutting edge of steel, which, by being obliquely placed, cuts two *bevelled* straps out of the rectangular one. In the ordinary way of making welts, the shoemaker shaves them away near one edge with a knife.

The soles are hardened by being passed between rollers (instead of by the ordinary process of hammering), and are then inlaid with the small nails, over all that broad part of the sole which is subjected to the greatest wear. These nails are not for the purpose of fixing the shoe together, but merely to strengthen the natural quality of the leather. All the holes for these nails are punched by a machine. The awl is fixed to the end of a lever: the sole is placed down flat upon a table, and by placing the foot on a treadle, the awl is made to descend and pierce the leather with the utmost precision and regularity, in as many places as may be required.

The next process is, perhaps, the most beautiful of all.

The nails are actually made,—inserted in the holes,—and driven in, without the hand of the attendant being any otherwise engaged than in holding the strip of iron from which the nails are cut. There is a pair of shears moved by a treadle for the man's foot: he inserts a strip of sheet-iron between the shears, and a short nail is instantly cut off by the descent of the treadle. This nail drops, point downwards, into a little cell, which diminishes to a minute tube exactly over one of the soles placed beneath it. The point of the nail thus falls into the hole of the leather, and a blunt punch or driver immediately descends and drives it in. One single pressure on the treadle performs the double office of driving in one nail, and cutting another from the strip of sheet-iron. When all the nails are thus partially driven in, the sole is removed from the machine, and a few blows with a hammer drive them wholly in.

The sole is now, by another machine, punched with another series of holes to receive the *tacking-nails*, or those which fasten the sole to the welt. The nails are then driven into these holes by a process similar to the one just described, so that their points are left protruding through one surface of the sole. On these points the welt is laid, being bent round to the shape of the sole by the help of a guide or mould; and the welt is then firmly hammered down upon these points, and thus united to the sole. The edge or outline of the sole and the welt are then cut and shaped similarly and made smooth by a revolving-machine.

The sole, with the welt attached, is then subjected to another punching, by which holes are made completely round the outer edge, and the *long nails* are inserted in these holes, by a machine similar to that before described. These nails are for the purpose of fixing the whole shoe together. The inner sole is first laid on the bottom of the last, and secured there. The upper leather is next formed and secured round the sides of the last, so as to fit it in every part, with an edge projecting three quarters of an inch all round: this edge is to form the *turning-in*, between the two soles. This projecting edge being turned over, is pasted down upon the bottom of the inner sole (which is uppermost). On this, the under sole is laid, with the points of the nails projecting from it; and these points being guided to their proper places, are hammered firmly down into the inner sole and turning-in, so as to make all unite firmly together. The points of the nails, after passing through four thicknesses of leather, come in contact with the steel face of the last, and are there clamped or bent

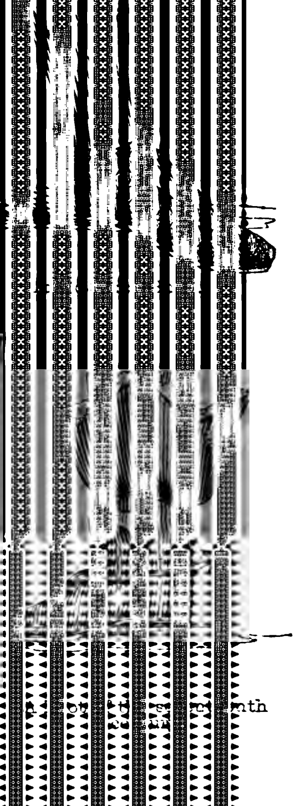
sideways by the pressure. These are afterwards rendered quite smooth by a subsequent hammering.

The shoe is now roughly made, and is finished off by a few subsequent processes. The sole is rasped with a coarse file, to level all the nail heads, and to render the leather smooth. It is then carried to a grindstone, where it is polished and finished up in every part, the sole blacked and polished by the wheel with a composition of bee's-wax and ivory-black, which renders it glossy. The upper leathers are then brushed with a circular brush, and the shoe is finished with the exception of binding or lining, which, if required, are done by hand.

Such is an outline of the curious routine by which machine-made shoes are produced. Wherever fashion requires a certain elegance of form and finish, it is probable that the manufacture by hand will never be superseded; but it is not unlikely that strong common shoes may at some future time be generally made by some such a combination of machinery as that above described.

The various trades concerned in the manufacture of leather form an important part of our national industry. It is supposed that 200,000 cwt. of hides are imported into England yearly;—that fifty million pounds of leather are tanned in England in the same period; that the value of the shoes and boots made in the same time is seven millions sterling, and of all other articles of leather, five millions.

The following forms of coverings for the feet may serve to amuse the reader.



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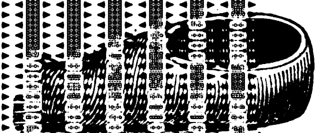

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Chapter IX.

MISCELLANEOUS PROCESSES.

In reviewing the details of the preceding chapters, the reader will see that we have gone over the most important portion of our ground. Cotton, linen, wool, fur, silk, and leather, in the various forms which they may be made to assume, constitute almost every article, every shape, every quality, and every colour, of our clothing.

It forms no part of our purpose to describe the modes in which woven fabrics are made up into garments; those modes are as various as the forms of the garments we wear; while the labours of the tailor, the dressmaker, and the milliner, are sufficiently familiar to all, so far as regards the use of the scissors and the needle; and matters of taste and fashion could be but ill treated in our little volume. We therefore prefer to devote the remainder of our space to subjects with which the general reader may not, perhaps, be familiar.

Furs were slightly alluded to in the chapter relating to hat-making; but a few additional remarks may be desirable. The attempts which have been made to render our clothing *water-proof*, demand a passing glance from us: and the *metal-button* is (subject to the fluctuations of fashion) an elegant appendage or fastening, not unworthy of a few words of description. *Shoe-buckles* may also be noticed as a striking example of the instability of any branch of manufacture which depends for its support merely upon custom or fashion.

Furs.

Beaver fur for making hats is brought from North America: *fitch*, or the fur of the fitchet or pole-cat, is principally imported from Germany: it is soft and warm, but its unpleasant smell depresses its value. *Martin* and *mink* (a diminutive species of *otter*) are principally imported from the United States and Canada: the fur of the *musquash* or *musk-rat* (a diminutive species of beaver) is imported in vast quantities from our possessions in North America; which also supplies us with considerable quantities of *otter* skins. Neutria skins are principally brought from Buenos Ayres:

the more valuable furs, such as ermine, sable, &c., are derived principally from Russia.

It was stated, in the introduction to this volume, that fur, or the skins of animals, formed the material from which dresses were made, before the use of woven fabrics became prevalent. Furs are now principally employed on account of the great beauty of their appearance; while most of them possess a degree of warmth which does not belong to woven fibres. Canada and Russia are the two countries where the principal portion of the animals which produce these furs are still to be found, so that the trade for furs forms no inconsiderable part of the commerce between England and those countries; and such is the eagerness with which the animals are hunted and killed for their skins, that we may look for a gradual diminution of the supply.

When the French became acquainted with Canada, two or three centuries ago, they purchased of the native Indians, for a mere trifle, large quantities of beautiful skins. By degrees the stock became exhausted near the settlements, and the French induced the Indians to take long journeys into the interior, for the purpose of capturing beavers, otters, &c. The hunters, when the hunting season was over, used to come down the river Ottawa into the St. Lawrence, and so to Montreal, which was then the chief settlement in Canada. Here the skins were bartered for trinkets, knives, hatchets, kettles, blankets, cloth, arms, ammunition, and—unhappily for humanity—ardent spirits.

A change then occurred in the mode of managing the traffic. Companies of Europeans, called *wood-rangers*, would take boat at Montreal, and go up to the hunting-grounds of the Indians, with their boats laden with such articles as the Indians preferred to take in barter for skins. When the barter was concluded, the wood-rangers would return to Montreal with their boats laden with skins, often after an absence of several months.

The English then took up the trade, not in Canada, but in the vast region known as British North America. A company was formed in 1670, with the exclusive right of trading for furs with the Indians of these countries. Another company, called the North-West Company, was established for a similar object in 1783; but as there arose instances of jealous interference between the agents of the two companies, they combined their interests, and have remained ever since an active but united company. They employ a large number of agents, clerks, and servants, who are scattered over the North American territory: and these

individuals undergo great hardships in their long and perilous journeys to the hunting countries. Sometimes they travel to no less a distance than four thousand miles from the European settlements on the St. Lawrence.

The furs, after being procured from the Indian hunters by barter, are brought to England. An annual sale takes place in London in the month of March, and at this sale not only English but foreign merchants attend, the latter coming principally from Germany. The furs for English use are sold to the English dealers; while those for the foreign market are taken to the great mercantile fair at Leipsic, from whence they are distributed to every part of continental Europe. The number of skins of fur-bearing animals imported into England amount to the very large quantity of two millions and a half annually; of which about three hundred thousand are re-exported. It must be borne in mind that a considerable portion of the skins thus imported are used for the purpose of making *hats*, particularly beaver and neutria furs. Every year neutria fur becomes more and more employed for hats, on account of the rapid diminution of the supply of beavers.

Those portions of the furs of animals which are not employed for hats, are prepared on the skins, in order to be fashioned into tippets, muffs, boas, cloaks, and the various forms which every succeeding winter presents to our view. Were these skins thick, the animal substance of which they are formed would require a great deal of preparation to remove the decomposing quality. But their thinness renders a comparatively slight process of dressing sufficient for the purpose.

One of the most unfavourable circumstances connected with the use of fur, is its liability to the attacks of a peculiar species of *moth*. The eggs of these insects are frequently laid near the roots of the hair; and it is then difficult to save the fur from destruction.

Waterproof Clothing.

Although the great object of clothing is to shield the body from vicissitudes of temperature, it must be admitted that to keep out *rain* is also a very desirable object. This has, until a comparatively recent period, been no easy matter, without imparting to garments a rigidity which would greatly incommode the wearer.

One resource, which has been very frequently resorted to, is to line the garment with oiled silk, such as is used for

hat and umbrella covers: that is, silk that has been dressed with a varnish of drying linseed-oil, which prevents the admission of water. This effectually guards the wearer of such a garment from becoming wet; but its effect is far from perfect, for the outside cloth is still exposed to rain, and can imbibe moisture, which will evaporate, and cause great part of that coldness which renders wet clothes so prejudicial.

Numerous attempts have been made within the last fifty years to prepare a varnish which, when applied to the surface of cloth, would enable it altogether to repel water. Mr. Angel, in 1781, proposed a varnish to be made of the following ingredients:—1 gallon of linseed-oil, 1lb. of bees-wax, 6lbs. of glue, ¼lb. of verdigris, ¼lb. of litharge, and 2 quarts of water; the whole to be placed in an iron kettle, melted, and applied to the cloth. It does not appear, however, that this varnish met with much success.

Caoutchouc, or Indian rubber, early engaged the attention of manufacturers; but great difficulty was encountered in liquefying it; or, if liquefied, of restoring it again to the solid form. At length, substances were found that would effectually dissolve it; and the following patent, taken out in 1797, will show the manner in which it was proposed to use caoutchouc as a water-proofing material. "The article to be operated upon must first be cleansed from all grease or dirt by washing it with an alkaline solution, and then stretched in a frame. The water-proof compound is formed by dissolving caoutchouc or Indian rubber in spirit of turpentine (the smell of which is taken off by adding oil of wormwood and spirit of wine in equal quantities); this forms a sort of varnish which is capable of being spread or washed over the surface of the leather or cloth, always applying it on the wrong side of the article, or that side which is not to be seen. The varnish is laid on by means of a large piece of Indian rubber, instead of a brush or sponge. To conceal the varnish, and make a good internal surface to the cloth, it must be sifted over with some substance, such as silk or wool, cut very fine, in the same manner as flock paper is made; and being left to dry, in a few days the flock, by its adhesion to the varnish, forms a very good lining, at the same time that it conceals the varnish." These waterproof cloths, which the patentee called "hydrolaines," were, however, but little used.

But the most important attempt at producing a water-proof varnish, and one that has met with complete success, followed the discovery that coal-oil (one of the products of gas-making) was an excellent solvent for caoutchouc, and

at the same time, could be purchased at an extremely low price. Mr. Mackintosh, a manufacturer near Glasgow, took out a patent in 1824, "for rendering fabrics of hemp, flax, cotton, wool, silk, and various other substances impervious to water." This is effected by the employment of a thick elastic varnish of caoutchouc and coal-oil. The proportion of the coal-oil required to dissolve a given quantity of the caoutchouc will vary according to the qualities of both; but the average quantity required is about a quarter of a pint of oil to a pound of caoutchouc. To facilitate the solution, the caoutchouc is to be cut into thin shreds, and the heat of a steam-bath employed; when the solution is completed, it is strained from the sediment.

To apply the varnish thus prepared, the cloth is stretched upon frames, and brushed over with it, and the varnished surfaces of two pieces of cloth, while in an adhesive yet tolerably hard state, are placed one upon the other, and passed between rollers subjected to pressure. A flexible and thoroughly waterproof material is thus obtained, applicable to a variety of useful purposes, without the exposure of the inconvenient and unpleasant varnished surface so common in other waterproof coverings.

The extent to which this valuable material for outer garments is now employed is very great, and is on the increase. The quantity of caoutchouc imported was very limited before its employment in this manner. In 1830 the quantity was about 50,000 lbs.,—in 1833 it was 180,000; and since that time it has increased enormously.

Gilt-Button Making.

The processes connected with the making of a gilt button are very ingenious, and deserve a brief notice.

A plain gilt button is formed of copper with a little alloy of zinc. The metal is rolled in a mill to the requisite thickness, and cut out into blanks the size of the intended button, by means of a stamp or punch worked by a fly-press. The shank is then formed, by twisting a piece of brass wire into a spiral form, and cutting off one turn of the spiral for each shank: or else, a piece of wire is introduced into a small engine, which cuts it off to the proper length, and bends it into a hoop-form over a pin.

The shank thus formed is applied in its proper place on the back of the button, and a little solder and resin applied

to it. It is then placed on a sheet of iron, and introduced into a very hot stove, where it remains till the solder has melted and the shank has united with the blank. Of course a large number of buttons are operated on at one time.

After the edges have been smoothed in a lathe, the buttons are put into an earthen vessel full of small holes, and dipped into dilute nitric acid, to cleanse them from dirt and rust. They are then fixed in a kind of lathe, and burnished with a hard black stone, procured from Derbyshire, by which small pores, &c., are filled up.

The buttons are then to be *gilt*. They are first put into a solution of mercury in nitric acid, and stirred about till a thin coating of the metal adheres to the button. They are then transferred to a vessel full of holes, where they are shaken till the superabundant mercury is removed from their surfaces. Some mercury is next put into an iron ladle, and a very minute quantity of gold added, and heated until the gold is perfectly dissolved in the mercury. The amalgam is then strained through a piece of chamois (or shamoy) leather. What remains in the leather is about as thick as *butter*, and it is put into an earthen vessel, with the addition of a little nitric acid. Into this solution the buttons are thrown, and kept there till a thin stratum of the amalgam attaches to the whole surface.

The gold continues to be combined with the mercury during the foregoing process; and the next thing is to dissipate the mercury by means of heat. The buttons are put into a pan over the fire, and shaken about till all the mercury becomes driven off in the form of vapour. This, however, does not occur without repeated changes in the position of the buttons: they are first stirred about in the pan, then removed from the fire, and again stirred in a sort of bag, then transferred a second time to the bag, and so on three or four times. This plan, which is now superseded by a better, was attended with great disadvantages, which have been thus detailed.

"By these means the principal part of the mercury ascended the chimney, and was deposited on the top of the houses and about the adjacent neighbourhood, and great quantities were inhaled and absorbed by the operator, keeping him nearly in a state of salivation, till disease obliged him to desist. Every one who has formerly visited our button manufactories at Birmingham, and elsewhere, can bear testimony to the emaciated state of the parties, mostly women, employed in this unhealthy process. Considerable quantities of mercury, thus volatilized, are found

united and collected in small pools in the spouts and gutters on the top of buildings. Thus many tons of mercury have been dissipated about the town and neighbourhood, to the great injury of the inhabitants. The poor sweep who has ascended the chimney has been salivated, and the manufacturer has sustained considerable loss." These evils have been to a great extent removed by an improved form of furnace, in which nearly the whole of the volatilized mercury is recovered for future use.

After the mercury is driven off by heat, the button presents a golden surface, which, after being laid aside for some time to dry, is finally burnished and brought to the beautiful state with which we are familiar. Notwithtanding the solidity of the appearance of the gold, it is so inconceivably thin, that one pennyweight of gold (one-twentieth part of an ounce) will gild seven hundred buttons.

Shoe-Buckles.

Although shoe-buckles can scarcely be said to form an existing branch of manufacture, yet the trade in them was, till very recent times, highly flourishing. Its history is in many respects curious, and deserves a place among our miscellaneous notices.

The buckle was preceded, and has been superseded, by other forms of shoe-fastening. "Perhaps the shoe, in one form or other," says Mr. Hutton, of Birmingham, "is nearly as ancient as the foot. It originally appeared under the name of 'sandal;' this was no other than a sole without an upper leather. That fashion has since been inverted, and we now, sometimes, see an upper leather nearly without a sole. But, whatever was the cut of the shoe, it always demanded a fastening." Under the house of Plantagenet, the shoe shot forward horizontally from the foot to an enormous length, so as to require the extremity to be fastened to the knee, sometimes with a silver chain, at other times with a silk lace, and even with a piece of common packthread. This enormous beak to the shoe became the subject of legislative enactment; for we find that, in 1465, an order of council was issued, prohibiting the wearing of shoes whose beaks projected more than two inches in front of the foot, on pain of a fine to the king, and even of excommunication.

When this fashion changed, the rose shoe-toe sprang up, in compliment to the houses of Lancaster and Tudor.

This rose in its turn gave way to shoe-laces and strings, which were often made of silk, tagged and fringed with silver. At length, in the reign of William and Mary, the shoe-buckle made its appearance; or, as Mr. Hutton quaintly expresses it, "the Revolution was remarkable for the introduction of William, of liberty, and the minute buckle." This mode of fastening the shoe became very generally adopted, in foreign countries as well as our own; and the town of Birmingham became celebrated for the large number as well as the excellence of the buckles made there.

Seventy years ago, the kind of buckle most in demand was made of Pinchbeck—an alloy of copper and brass, so called from the name of the person who so employed it. Another variety was the plaited buckle: this was cast in pinchbeck, with the pattern on its surface, and a silver coating was laid on by means of a flux of turpentine and resin; and the surface was finally chased or stamped. A third and more valuable quality was the "close-plated" buckle. A form of buckle extensively made for foreign sale, was produced from a compound metal known among the workmen as Tutannia, and cast in moulds. It is said that in Germany, this article was manufactured in the open streets, so that a passenger might choose his pattern, see the process of making, and march off equipped with shoe-buckles, in the course of five or ten minutes. Each form of buckle had at that time some fanciful name, by which it was known in the trade; such as, "Bull's eye," the "Marquis of Granby," the "Whim-wham," "Job's fancy," the "Crow's foot," and others.

About the year 1778, an impulse was given to the buckle-trade at Birmingham, Walsall, and Wolverhampton, by the invention of plating upon tin or composition foundations. The buckles were cast singly by hand, in tin or copper moulds, the silver being first pressed into the mould, and the composition then poured over it. The intimate union of the metals was aided by the use of corrosive sublimate. Different metals were employed, such as copper, steel, spelter, and others, to give hardness to the tin. This plan gave birth to the many elegant devices in the shoe-buckle, as the union of the silver with the metal beneath was so complete as to admit of a varied range of patterns and arrangement of ornaments; particularly that of inlaying yellow chased ornaments on the surface of the silver.

A peculiar arrangement of the *chape*, a part of the buckle which fastened the shoe, enabled the manufacturer to give

almost any size to the buckle, and to adopt a variety of shapes, such as round, octagonal, oval, oblong, &c. The competition among the makers now became very active; and a consequence resulted which too frequently deteriorates the credit of those employed: the materials and mode of workmanship became worse in quality, in order that the selling price might be low. It is said, that for many years the consumption of buckles in the metropolis was so enormous, that half the luggage of the coaches going from Birmingham to London was supposed to consist of buckles.

Soon after this period, a further change took place in the mode of manufacture, by making the shell or foundation of one metal, placing a layer of tin on that, and plating the exterior surface with silver. Another kind was the silvered buckle, in which the exterior layer of silver was excessively thin. The buckle being cast in some cheap metal, fine silver was dissolved in aqua-fortis, and precipitated in a powder; a few chemical ingredients were added, and the whole brought into a liquid state, and spread over the buckle with a brush. The buckle was then placed on a gentle fire till the ingredients were fused, and after a few other processes, the buckle acquired a silvery whiteness. This silvery surface would bear burnishing, and had a good appearance; but it was soon rubbed off by wear. So large was the demand for buckles coated with silver, that one Birmingham maker produced for one foreign house four thousand pounds' worth in the space of six months.

Mr. Luckcock, of Birmingham, who wrote on this subject, says that many a princely fortune was acquired during the efforts and fluctuations in the buckle-trade, and not a few as profusely squandered. No anticipation was contemplated of any falling-off in the demand. But the time was approaching when the buckle was to be superseded by another form of shoe-tie. "About the year 1790, the foe commenced an insidious attack; and however insignificant the agent might at first appear, the *shoe-string* was destined to accomplish the mighty revolution. For a long time the advances were inconsiderable, and hope was sanguine that the whim would be but of short continuance. Every manufacturer gradually felt the ground falling from beneath his feet, but still supposed that his competitors were doing better than himself; till confidence itself at length gave way to the general panic, and, if one may so express it, 'those were best off at last who got out first.'" The manufacturers, as generally happens in such cases, thought themselves aggrieved; but by whom was not an easy

question to answer. They first tried ridicule, in a way which, it must be confessed, was sufficiently weak and foolish: viz., to parade an ass through the streets of Birmingham, with shoe-bows attached to his fetlocks. A more rational course adopted, was to send a deputation of master manufacturers up to London, to wait on the Prince of Wales (afterwards George the Fourth) at Carlton House, and solicit the aid of his countenance and support. The prince received the deputation courteously, and promised to do all which his personal influence could effect, to discourage the use of the shoe-tie. But all to no effect; taste, fashion, opinion, call it what we will, had taken such a decided turn, that from that time (1791) the use of the shoe-buckle declined every year more and more.

Mr. Luckcock, who had himself been in the buckle-trade, estimated the number of persons engaged therein, in and about Birmingham, at upwards of four thousand, when the manufacture was in the zenith of its prosperity; and he made the following calculations to show the importance of this trade. Suppose the weekly earnings of these persons, young and old, to have averaged ten shillings each,—

This would produce	£2000
Materials, say	2000
Profit of manufacturer, retailer, &c.	2000
	6000
Weeks in the year	52
	£312,000

And supposing the buckles to sell, on the average, at 2*s*. 6*d*. per pair, (this may now-a-days seem a high average; but a guinea or upwards was not an unusual price for gentlemen's buckles at the period of which we are speaking,) this would show 2,496,000 pairs as the quantity annually made. Taking the population of Great Britain at that time to be twelve millions, and suppose half of them to wear buckles, this would allow each wearer a new pair every three years, and about half a million of pairs for exportation, which is deemed no improbable supposition. On this calculation, every workman would make 625 pairs during the year, about two pairs per day, excluding Sundays. These calculations are of course only approximative; but they furnish curious evidence of the fluctuations to which manufactures are liable; and they are valuable as showing how necessary education and provident habits are to the workman, since he can never tell how soon a

change may occur which will compel him to turn his talents into some new department of labour.

We will conclude by quoting a remark from Mr. Luckcock, who wrote in 1824:—"Of all the mutations and revolutions which this town has experienced within the last fifty years, none appear to be so remarkable or extraordinary as those connected with its ancient and apparently invaluable shoe-buckle trade. To those of the inhabitants who remember its vast extent and importance, it seems almost to mock at recollection; and as to the present generation, if the fact was not authenticated while some few of the surviving witnesses remain, it must soon have appeared incredible, that at one period there were not fewer than four thousand persons employed in the town and neighbourhood in this article, at that time so much admired, though now neglected and almost unknown. The universality of the demand seemed to bid defiance to the future caprice of fashion; and our daily bread appeared quite as likely to fail in its supply, as that orders should totally cease for this elegant and imagined necessary ornament."

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